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Geology of the
Rawhide Lake Area

District of Algoma

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J. Wortsale
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Geological Maps

(back pocket)

Map 2305 (coloured)—Viel and Piche Townships, Districts of Algoma.
Scale, 1 inch to ½ mile or 1:31,680.

Map 2306 (coloured)—Hembruff and Hughson Townships, District of Algoma.
Scale, 1 inch to ½ mile or 1:31,680.

ABSTRACT

The Rawhide Lake area (Viel, Piche, Hughson, and Hembruff Townships) is underlain by Early Precambrian (Archean) igneous and metamorphic, Middle and Late Precambrian (Proterozoic) sedimentary and igneous rocks, and Pleistocene and Recent unconsolidated sediments. The Archean rocks constitute the basement on which the Huronian (Proterozoic) sedimentary rocks lie unconformably. Only Upper Huronian sedimentary rocks are in this area, and these can be assigned to four formations: Gowganda, Lorrain, Gordon Lake and Bar River, in ascending stratigraphic order. There are mafic intrusive rocks of several ages.

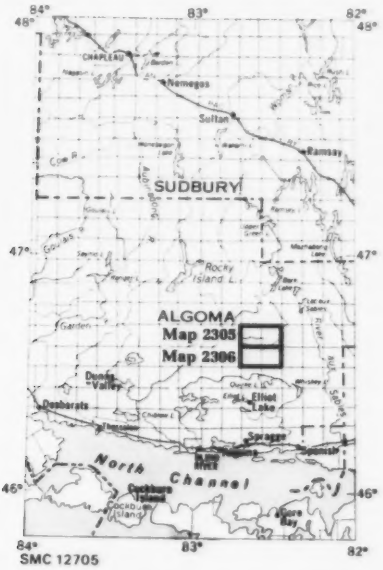

Figure 1–Key map showing location of the Rawhide Lake Area. Scale 1 inch to 50 miles (1:3,168,000).

Archean metavolcanics and metasediments are the oldest rocks in the area. The original composition of the metavolcanics ranges from basalt to rhyolite and includes porphyritic and pillowed varieties. The metasediments include pebble conglomerate (basaltic, rhyolitic, granitic pebbles), wacke (mostly lithic subarkosic wacke), and argillite with staurolite and garnet common in the more argillaceous types. The rhyolitic rocks are generally associated with the sedimentary rocks. Metamorphic assemblages vary from middle to upper greenschist facies to lower almandine-amphibolite facies; there were at least two phases of metamorphism. Several structural deformations have affected the Archean volcanic and sedimentary rocks. All planar and metamorphic structures have a steep dip and refolded folds are common.

Mafic intrusions postdate the metavolcanic-metasedimentary sequence but predate the Archean felsic intrusive granitic rocks.

The two oldest Archean intrusive granitic rock types are a foliated quartz diorite and a compositionally heterogeneous quartz monzonite. These are distinguishable from the younger granitic rock types by their abundant inclusions. The composition of the older granitic rocks can be related to the xenoliths present. The younger granitic rocks contain no inclusions, are homogeneous, have no mineral foliation, and are intrusive into the other granitic rocks. Pegmatites and aplites are associated with both the older and the younger granitic rock types.

There is a post-Archean pre-Huronian generation of mafic intrusions.

The Huronian formations consist of various types of conglomerate, arkose, wacke, siltstone, shale, and intraformational breccia. Diaspore, kaolinite, pyrophyllite, anhydrite, gypsum, hematite, and radioactive minerals are in some of these formations. Ripple-marks, shrinkage structures, and sedimentary intrusions are abundant in the Huronian rocks.

Rocks of the Gowganda Formation were deposited under frigid climatic conditions and although some are water-laid, others may have been deposited directly from glaciers. Sediments of the Lorrain Formation are believed to be fluvial deposits. The cold climate prevalent during deposition of the Gowganda Formation had moderated to a tropical one by the end of deposition of the lower part of the Lorrain Formation. This tropical climate continued throughout the time of the deposition of the Lorrain Formation sediments. It is considered that the loessic material which comprises much of the Gordon Lake Formation was initially produced by glacial action and subsequently blown into a basin of deposition. The sedimentary rocks of this formation are believed to have been deposited in a tidal flat environment. The sedimentary rocks of the Bar River Formation were deposited in a beach environment and subjected to reworking by wind.

The hematite beds in the Lorrain Formation, the hematite ooliths, and gypsum anhydrite nodules in the Gordon Lake Formation, and the hematitic cement in the Bar River Formation suggest that the atmosphere at the time of deposition of the upper Huronian rocks was oxygenic. The Lorrain Formation is a potential source of thorium if a market for this element should develop.

Geology of
the Rawhide Lake Area
District of Algoma

By

J. Wood[1]

INTRODUCTION

The Rawhide Lake area is located in the District of Algoma, north of Lake Huron, about 20 miles (30 km) north of Elliot Lake and includes Viel, Piche, Hembruff, and Hughson Townships[2], totalling 144 square miles (369 square km). The area was mapped on a scale, 1 inch to ¼ mile (1:15,840) and preliminary maps (Wood 1968b,c; 1969a,b) were published at this scale. The final map (back pocket) is at a scale, 1 inch to ½ mile (1:31,680).

Highway 546 from Iron Bridge provides access to the northwestern part of the map-area whereas Highways 108 and 639 provide access to the southwestern part of the map-area. Float-equipped aircraft are available from Lauzon Lake or Elliot Lake and were used by the field party for access to the more easterly localities.

History of Previous Work

The area was mapped for the Ontario Department of Mines in 1937 by W. D. Harding (1939) and a map at a scale, 1 inch to 1 mile or 1:63,360, was published to accompany that report. Although there was prospecting activity in the general region of the North Shore of Lake Huron from as early as 1846, the early prospectors probably did not reach the Rawhide Lake area. W. H. Collins of the Geological Survey of Canada mapped the Blind River region in 1914 to 1916 (Collins 1925). The northern boundary of his map-area coincides with the southern boundary of the present one.

Following the discovery of uranium in the Blind River district in 1953, the Blind River-Elliot Lake region including the area under study, was extensively staked. Exploration activity which included diamond drilling was carried out in and around Rawhide Lake, but no development work was undertaken.

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[1]Geologist, Precambrian Geology Section, Geological Branch, Ontario Division of Mines, Toronto. Manuscript accepted for publication by the Chief Geologist, 21 May 1971.

[2]Viel, Piche, Hembruff, and Hughson Townships were formerly Townships U, Q, 151, and 145, respectively.

Rawhide Lake Area

In 1961 part of the area was withdrawn from staking and incorporated in the Mississagi Provincial Park. Exploration for copper was carried out in the Stag Lake area during 1964 and 1965.

The realization in the mid-sixties that the known world reserves of uranium were insufficient to meet needs much beyond 1980 combined with an increase in demand for uranium led to a renewal of interest and staking activity in the area. In February 1968 much of the ground, including part of the area presently under study previously within the Mississagi Provincial Park, was re-opened for staking and since then considerable exploratory activity, including diamond drilling, has taken place.

To date no results from the work of the mining companies in the area have been published. Geological and geophysical data have, however, been submitted for assessment credit.

Synchronously with the discovery of economic uranium deposits in the Blind River-Elliot Lake area in 1953, both the Ontario Department of Mines and the Geological Survey of Canada undertook work programs: the Ontario Department of Mines concentrating on the regional mapping and the Geological Survey of Canada on a detailed study of the ore deposits and their geological relationships. In a paper on the 'Geology and Radioactive Deposits of the Blind River Region' by S. M. Roscoe and H. R. Steacy (1958), in a later paper on 'Huronian Rocks and Uraniferous Conglomerates in the Canadian Shield' by Roscoe (1969), and in a report by G. H. Eisbacher and H. N. Bielenstein (1969, p.58-60) entitled 'The Flack Lake Depression', the area presently under consideration receives passing mention. J. A. Robertson (1963; 1969a,b; 1970b), Ontario Division of Mines, has produced maps of and reports on areas to the south and west of the map-area. M. J. Frarey of the Geological Survey of Canada has produced maps of the region between Blind River and Sault Ste. Marie (see Robertson, Card and Frarey 1969, p.20-26). No detailed reports on this work of the Geological Survey of Canada have appeared to date.

Topography and Drainage

Topographically the area can be divided into two parts. The part underlain by Archean rocks is undulating with local irregularities, whereas the part underlain by Huronian sedimentary rocks is characterized by east-west-trending dip and scarp topography. Scarp slopes face northwards and may be up to 400 feet (120 m) high. Bedding planes generally coincide with dip slopes.

The average lake elevation is approximately 1,300 feet (400 m), e.g. Rawhide Lake, 1,320 feet (402 m); Rottier Lake, 1,288 feet (392.6 m); Semiwite Lake, 1,332 feet (405.9). The elevation of the area varies from about 1,100 feet to 1,800 feet (340 m to 550 m) with a maximum local relief of about 400 feet (120 m).

The area is drained by three different river systems: the Boland River-Little White River System, the Serpent River System, and the River Aux Sables System. A dam from early lumbering activity on Rawhide Lake can be used to control run-off from that lake into the Little White River System. The streams are parallel

to the strike of sedimentary formations, to faults, to dike directions, and to principal joint directions. The shape of the lakes reflect these same geological features.

Resources

The known mineral resources of the area are limited, but present exploration work may lead to the finding of new wealth.

Some sand and gravel deposits in Hembruff and Viel Townships are being exploited. There are many such deposits throughout the area, but the lack of roads or good water routes prevents their being used.

There is evidence of lumbering activity throughout the area. During the summer of 1967 logging was carried out in part of Viel Township. Small hydro-electric power stations (for local power supply) could be built.

The lakes coupled with the rugged scenery are a great attraction for tourists.

There is a considerable variety of wildlife in the area: moose, deer, and bear are common.

Methods of Mapping

The amount of bedrock exposed varies in the map-area and is dependent on the extent of the glacial deposits. Aerial photographs at a scale 1 inch to ¼ mile (1:15,840) were used in the field and all outcrops visible on these photographs were visited. In areas of no visible outcrop, systematic pace-and-compass traverses were made at ¼ mile (0.4 km) intervals.

Acknowledgments

The author expresses his thanks to R. H. Pinsent (1967, 1968), E. G. Anderson, J. M. Kowalchuk, and C. J. Monahan (1967) and P. W. Severin, B. D. Stewart, and R. H. Venter (1968), for capable help rendered in the field. Pinsent was responsible for a considerable part of the mapping.

The many courtesies extended by Mr. & Mrs. Stewart McElrea of Frontier Lodge to the members of the 1967 field party are gratefully acknowledged.

Co-operation was received from personnel of the Ministry of Natural Resources located at Mount Lake and Christman (Jimchrist) Lake and from many area residents and mining company personnel. The author thanks G. M. Young of the University of Western Ontario, and K. D. Card of the Ontario Division of Mines and F. W. Chandler of the Geological Survey of Canada for many helpful discussions on Huronian geology. P. E. Giblin and Roy Rupert, present and former Resident Geologists at Sault Ste. Marie, are thanked for their help and kind co-operation. J. A. Robertson critically reviewed and offered suggestions on this report.

GENERAL GEOLOGY

The rocks occurring in the Rawhide Lake area can be assigned to seven major rock stratigraphic units:

7. Keweenawan-type mafic intrusive rocks
6. Nipissing-type mafic intrusive rocks
5. Huronian sedimentary rocks
4. Pre-Huronian mafic intrusive rocks
3. Archean granitic rocks
2. Archean metasediments
1. Archean metavolcanics

Unconsolidated Pleistocene and Recent deposits occur in the area.

Proterozoic Huronian rocks lie unconformably on Archean granitic rocks in the northern part of the area and are downfaulted against Archean metavolcanics, metasediments, and granitic rocks by the Flack Lake Fault in the southern part of the area. Nipissing and Keweenawan intrusions cut the Archean and Huronian rocks. The Keweenawan intrusions are the youngest consolidated rock types in the area.

The classification of sedimentary rocks used in this report (Figure 2) follows the scheme by Young (1967b) modified from Gilbert (1954), McBride (1963), and Dott (1964).

The classification of igneous rocks is based on that of I. C. Brown (1952).

The classification of metamorphic rocks follows F. J. Turner and J. Verhoogen (1960).

Visual estimates of roundness were made from the chart of M. C. Powers (1953).

Visual estimates of sphericity were made using the chart of G. Rittenhouse (1943).

Early Precambrian (Archean)

METAVOLCANICS AND METASEDIMENTS

The best exposures of Archean metavolcanics and metasediments are in the southern part of the area. Remnants of these rock types occur in other parts of the area especially in the migmatitic parts of the granitic terrain and in places where a "shadow stratigraphy" can be discerned as for example in the northwestern part of Viel Township. The schistosity in these rocks almost invariably parallels the northwest-southeast regional trend.

In the south a belt of Archean metavolcanics and metasediments extends east-west across the map-area. Ten mappable units occur in the belt and, although pillowed lava flows may provide top determinations, they are too few for the precise outlining of the stratigraphy. There has been extensive folding in this region which has made the interpretation of the geology difficult. However after comparison with other areas (Goodwin and Shklanka 1967), mafic volcanic rock-felsic volcanic rock-sedimentary rock sequences became apparent. Lateral facies

Table 1 | TABLE OF LITHOLOGIC UNITS FOR THE RAWHIDE LAKE AREA

CENOZOIC

QUATERNARY

RECENT

Stream gravels, sand, and swamp deposits

PLEISTOCENE

Gravel, sand, and till

Unconformity

PRECAMBRIAN

LATE PRECAMBRIAN (PROTEROZOIC)

KEWEENAWAN

Olivine diabase (Sudbury dikes)

Intrusive Contact

MIDDLE PRECAMBRIAN (PROTEROZOIC)

NIPISSING INTRUSIVE ROCKS

Quartz diabase, quartz diorite-granodiorite, diorite, gabbro

Intrusive Contact

HURONIAN SUPERGROUP

COBALT GROUP

BAR RIVER FORMATION

Quartz arenite, subarkose, quartz wacke, shale

GORDON LAKE FORMATION

Subarkose, subarkosic wacke, shale, mudstone, sandstone argillite

LORRAIN FORMATION

Quartz arenite, conglomerate quartz wacke arkose, subarkose

GOWGANDA FORMATION

Arkose, subarkosic wacke, mudstone, paraconglomerate, orthoconglomerate

Great Unconformity

PRE-HURONIAN INTRUSIVE ROCKS

Quartz diabase

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)

FELSIC INTRUSIVE ROCKS

Quartz diorite, magmatitic quartz monzonite, porphyritic granodiorite, equigranular granodiorite, red-brown quartz monzonite, fine-grained granite, white quartz monzonite.

Intrusive Contact

MAFIC INSTRUSIVE ROCKS

Basalt, metadiabase

Intrusive Contact

METAVOLCANICS AND METASEDIMENTS

METASEDIMENTS

Arenaceous conglomerate, arenite, wacke, and mudstone, argillaceous siltstone, mudstone, and schist, iron formation

FELSIC METAVOLCANICS

Rhyolitic rocks, siliceous tuffs, porphyritic rhyolite

MAFIC METAVOLCANICS

Basalt, porphyritic basalt, pillow lava, feldspathic amphibolite sheared mafic rock

changes are common. The intensity of deformation decreases from east to west along this belt. The metavolcanic and metasedimentary inclusions within the granitic terrain will be discussed after the section dealing with the granitic rocks.

Mafic Metavolcanics

The volcanic rocks are schistose except in the southwestern part of Hembruff Township where some equigranular basalts may be confused with Nipissing-type diabase. Although the Table of Lithologic Units (Table 1) and the map legend refer to the rock types in terms of their probable original composition, all the rocks have been metamorphosed. The metamorphic facies varies from the lower greenschist facies to the staurolite-almandine subfacies of the almandine-amphibolite facies.

Equigranular Basalt

The most common volcanic rock type appears to have been equigranular basalt (Code 1a on Geological Map, back pocket). This is now represented by rock types varying from dark greenish chloritic schist with some remnants of original pyroxene, for example in the southwestern part of Hembruff Township, to a quartz-feldspar-hornblende schist as in most other occurrences in the area.

Throughout the area there are occurrences of pillowed basalt (1c). Apart from the outer parts of the pillows which are lighter coloured than the pillow interiors and considerably altered, the mineralogy and texture of the pillowed flows is identical to that of the unpillowed basaltic flows with which they are associated. The degree of development of schistosity and the shape of the pillows varies according to the degree of local deformation. Thus south of Semiwite Lake the pillows are relatively undeformed (Photo 1) whereas southeast of Rooster Lake the width of the pillows greatly exceeds their thickness such that the pillow cross section resembles the longitudinal cross section of a sausage.

The mineralogy of the basalt varies with the degree of metamorphism. In some of the lesser metamorphosed rocks, for example north of McElrea Lake, typical minerals are albite, actinolitic hornblende, quartz, chlorite, epidote, sphene, and magnetite. Remnants of original pyroxenes may, also, be observed in these rocks. Where the grade of metamorphism of the rocks is higher, for example west of Rooster Lake, the amphibole is a true hornblende; chlorite is absent; biotite is present; and the feldspar is albite. South of Semiwite Lake the principal minerals are: hornblende, minor biotite, oligoclase, and almandine. There is an increase in intensity of the foliation with increase of metamorphic grade.

Porphyritic Basalt

The main occurrence of porphyritic basalt (1b) is about 1 mile (1.5 km) southwest of Rooster Lake. It is black and, like the equigranular basalt, schistose. It has

ODM9040

Photo 1–Pillow lava, south of Semiwite Lake. Note the undeformed nature of the pillows and the abundant glacial striae.

pinkish feldspar phenocrysts which are deformed and oval in shape with their long dimensions parallel to the schistosity. The phenocrysts appear altered and albitized in thin section. They probably originally had the composition of an intermediate plagioclase. The relationship of this basalt to the equigranular type is not known, but field evidence suggests that there may be a gradation from one to the other.

Feldspathic Amphibolite

At different localities throughout the area, for example approximately ¼ mile (0.4 km) east of the east end of Semiwite Lake, there are small amounts of a distinctive coarse-grained equigranular amphibolite (1d).

Sheared Mafic Rock

Small areas of highly sheared green rock (1e) are present at different localities, for example on the north shore of Little Quirke Lake. These have been caused by the faulting and consequent shearing of mafic rock. It is impossible to deduce the original rock types, and they may have been either intrusive or extrusive.

Rawhide Lake Area

Felsic Metavolcanics

The grade of metamorphism and the associated deformation make it difficult to distinguish among the felsic volcanic rocks (2a), siliceous tuffs, and quartzo-feldspathic sedimentary rocks (3a), all of which occur at the same stratigraphic horizons.

There are two distinctly different modes of occurrence of rhyolitic volcanic rocks.

The first is in conjunction with mafic volcanic rocks, for example in the area directly south of the east end of Semiwite Lake where mafic volcanic rocks are overlain stratigraphically by grey to cream felsic volcanic rocks with or without siliceous tuffaceous material and/or various types of sediment. In such sequences the felsic and mafic flows are relatively thin and appear discontinuous laterally. The siliceous tuffaceous material may contain pyrite and minor amounts of chalcopyrite.

The second mode of occurrence is well demonstrated in the area 1½ miles (2.4 km) south of the east end of Semiwite Lake where there is a thick accumulation of felsic volcanic rocks. These rocks superficially resemble granitic rocks, but close inspection shows that they are very fine grained, very siliceous, and because of the lack of micaceous minerals are lineated rather than schistose. Similar accumulations occur in other parts of the area.

Siliceous tuffs were only recognized as such in a few places. They prabably were fairly extensive, but metamorphism has effectively removed their diagnostic features.

Porphyritic rhyolite-dacite (2d) is rare in the area mapped. There is an association between this rock type and porphyritic basalt, as shown 1 mile (1.6 km) southwest of the west end of Rooster Lake. The phenocrysts are feldspar, generally pale white, stumpy, and usually about 5 mm in length, whereas the mass of the rock itself has a medium grey colour similar to the equigranular rhyolites.

Metasediments

The sedimentary rocks in the area can be assigned to two broad categories: one arenaceous (3a), the other argillaceous (3b). This simple subdivision is used on the map with the exception of a particular type of arenaceous rock, namely iron formation which is given a separate code (3c) in the map legend. The iron formation is restricted to the southeastern part of Hughson Township; the other sedimentary rock types may be found throughout the southern belt.

Iron Formation

The best exposures of iron formation occur near the eastern boundary of Hughson Township just north of the Little Quirke Lake Fault. However a considerably larger area may be underlain by such material as evidenced by magnetic

anomalies as shown on Aeromagnetic Map 2257G (ODM-GSC 1963b). The rock type is distinctive in the field because of its magnetic effect and its light and dark banded appearance, the dark bands being rich in magnetite and the lighter bands rich in quartz.

In thin section it is apparent that magnetite, quartz, and hornblende are the main components, the blackness of individual bands being directly related to the amount of magnetite present. The orientation of the hornblende crystals, which are more abundant in the darker layers, gives the rock a poor schistosity.

Arenaceous and Argillaceous Rock Types

These generally occur in conjunction with one another. Original rock types varied from pebble conglomerate through arenite and wacke to mudstone, and are now represented by a variety of metamorphic rock types all of which have some degree of schistosity.

The conglomeratic rock type are rare in the area mapped and occur only in the western part of Hembruff Township; they are more widespread in Raimbault Township (formerly Township 157) to the west. The larger clasts rarely exceed pebble size and occur in a sandstone matrix, lithic arkose in composition. They represent a variety of different rock types including basalt, rhyolite, and granitic material. They are elongated parallel to the schistosity, but little stretching seems to have occurred.

The arenaceous rock types are now represented by massive to schistose rocks composed of quartz, feldspar, muscovite, biotite, and hornblende. These have a wider regional distribution than the conglomeratic rock types and may be found in many localities throughout the southern belt. In general they are associated with rhyolitic volcanic rocks and where there has been shearing, difficulty may be experienced in separating the two original rock types.

The argillaceous rock types, siltstone and mudstone, are represented by biotite-feldspar-quartz schists with or without garnet, staurolite, and muscovite.

The arenaceous and argillaceous types occur together and gradations from one to the other may commonly be observed. Graded bedding is the most common sedimentary structure and shows up in a spectacular fashion because of the development of staurolite porphyroblasts in the originally finer grained parts of a bed.

The amounts of muscovite, biotite, and hornblende are greater in the finer grained rocks; quartz and feldspar are major constituents of both rock types. Some of the arenaceous rocks must originally have approximated arkose in composition. The presence of hornblende in all of the clastic rocks examined and its rather infrequent occurrence as a metamorphic mineral in metasediments would suggest that the hornblende may have formed from detrital pyroxene from the weathering and erosion of basalts, or from original detrital hornblende from the weathering and erosion of andesite. In either situation, owing to the metamorphic grade, hornblende would be the resulting mineral. Staurolite and garnet are best developed in the argillaceous rocks south of Semiwite Lake. The garnets are generally quite small, but the staurolites may reach 1 cm in length. Although the

latter may be considerably altered, they are easily recognizable by their distinctive morphology and twinning.

Paleoenvironment

Because of the abundance of volcanic rocks, the environment of deposition of the Archean metasediments and metavolcanics should be described as eugeosynclinal. The presence of conglomerate and quartzose sediments is, however, unusual in such an environment and brings into question the validity of such a geosynclinal concept.

The number of volcanic cycles in the area is probably two, a complete cycle being:

sedimentary rock and tuffs
felsic volcanic rocks
mafic volcanic rocks

Individual volcanic centres were not recognized, but feeder dikes to lava flows were. The possibility that at least some of the volcanic rocks resulted from fissure eruptions must be considered. The presence of pillow lavas suggest that some submarine volcanic activity took place.

Most of the sediments were probably deposited in shallow water. The graded beds may have been deposited by turbidity currents, although these do not necessarily infer deep water. The amounts of coarse-grained, quartz-rich arenaceous rocks suggest that a granitic basement must have existed. The granitic pebbles in the conglomerate units substantiate this theory, even though all the granitic rock types as presently seen are intrusive into the metasediments.

The presence of abundant sulphide minerals near Samreid Lake in Raimbault Township to the west of Hembruff Township (Friedman 1959) suggests that there may have been a primary zonation in this volcanic belt in terms of sulphur and oxygen.

MAFIC INTRUSIVE ROCKS

(Post-Volcanic—Pre-Granite Intrusive Rocks)

These mafic intrusive rocks postdate the metavolcanic rocks and predate the felsic intrusive rocks. They are microgabbroic and dike-like in character. They are relatively small with individual intrusions being less than 1,000 feet (300 m) in width. A typical example occurs ¼ mile (0.4 km) west of Rooster Lake. Minerals are usually amphibole (hornblende) plagioclase, epidote, chlorite, and plagioclase alteration products in varying proportions. In the field the rocks are green and altered and do not show well defined chilled zones. In some localities these intrusive rocks are similar in mineralogy and texture to non-pillowed, non-porphyritic basalts and may be genetically related to them.

It is difficult in some localities to distinguish between these mafic intrusive rocks and the later mafic intrusive rocks.

FELSIC INTRUSIVE ROCKS

There are eight different mappable units of granitic rocks in the map-area. Further subdivision of these units is possible.

Quartz Diorite

The oldest granitic rock is in the neighbourhood of Applesauce, Alexander, Rooster, and Harry Lakes. Compositionally it is between a granodiorite and a quartz diorite. The boundary between these two rock types is set at plagioclase composition An_{30}. Inasmuch as the plagioclase composition of this granitic rock is An_{33}, the rock should be called a quartz diorite, although the quartz content is more in keeping with that of a granodiorite. Hornblende and biotite are essential constituents. They occur as randomly oriented crystals in parallel lenses which give the rock a distinct foliation, so that texturally it could be described as gneissic. This texture suggests that directed pressure acting on the intrusion during crystallization rather than after crystallization caused the foliation. If the latter had been the situation or if the material forming the rock had been intruded as a 'crystal mush', then bent or broken plagioclase, hornblende, and biotite crystals should be apparent. It seems unlikely that post-intrusion regional metamorphism was the cause of the foliation, because a strongly directed mineral orientation is not present in the rock. The rock has intrusive relationships with the adjoining volcanic rocks and near the contact coarse-grained inclusions of mafic volcanic material composed of hornblende and feldspar are abundant.

An aplite is associated with this quartz diorite (Photo 2).

Migmatitic Quartz Monzonite

The next youngest granitic intrusive rock forms a large part of the granitic mass in the area mapped. It is variable in composition but, in general, may be described as a quartz monzonite. The reason for the composition heterogeneity of this granitic intrusion is that it is largely migmatitic and has abundant inclusions of both metavolcanic and metasedimentary Archean rocks (Photo 3). These inclusions have fundamentally changed the composition of the 'granite' and the migmatitic phases result from the partial absorption of inclusions.

Associated with this phase of 'granite' are quartz-feldspar pegmatites (Photo 4) which commonly have graphic (or runic) texture. Both sodic plagioclase and microcline microperthite show graphic intergrowth with quartz. Micaceous and 'exotic' minerals are almost totally absent from these pegmatites.

Apart from the schistosity in inclusions of Archean metavolcanics and metasediments, no mineral orientation is present in this granitic mass. Field relations indicate that the quartz diorite previously described is older than this quartz monzonite.

ODM9041

Photo 2–Aplite stringers in quartz diorite, Rooster Lake. An inclusion is present near the bottom of the photograph.

ODM9042

Photo 3–Inclusion of meta-igneous rock within the granitic mass near Bass Lake. Note the composition change from top to bottom of the photograph.

ODM9043

Photo 4–Pegmatite veins cutting inclusion within the 'granite' near Bass Lake. The pegmatite is to the top left of the photograph.

Porphyritic Granodiorite (North)

A porphyritic granitic rock in the northwestern part of Viel Township is intrusive into the quartz monzonite and is inclusion-free in direct contrast to the quartz monzonite. A quartz-feldspar pegmatite is associated with this intrusion. Phenocrysts, up to 3 cm long, have a preferred orientation and are pink microperthitic microcline. This orientation is more likely due to flow rather than to synintrusional directed pressure, because the phenocrysts have not only their *c* axes parallel but also *b* axes and *a* axes. Other minerals present are quartz and plagioclase myrmekitically intergrown with microcline. Extensive mineral alteration precludes determining from relative indices of refraction and optic axial angles whether the plagioclase is albite or oligoclase. Some chlorite after biotite is present as well as magnetite, hematite, and epidote. Zircon is an accessory.

Porphyritic Granodiorite (South)

In the southern part of the area several miles east of Little Quirke Lake, there is a porphyritic granitic rock similar to the porphyritic granodiorite in the northwestern part of Viel Township. Microcline phenocrysts, generally with Carlsbad twinning, are up to 3 cm in length. The rock has a mottled appearance with an

equigranular groundmass of white feldspars, smoky-yellow quartz, and dark ferromagnesian minerals.

In thin section the phenocrysts of microcline contain inclusions of plagioclase, biotite, epidote, chlorite, and calcite. The groundmass consists of stumpy idiomorphic oligoclase crystals which show incipient alteration, biotite which in places has been partly altered to chlorite, quartz, sphene, pistacite, and some serpentine and hematite. Biotite, sphene, pistacite, and serpentine commonly occur in patches. These minerals may be the alteration products of pre-existing hornblende.

Non-porphyritic Granodiorite

Closely associated with the 'south porphyritic granodiorite' is an equigranular granitic rock containing subidiomorphic feldspar crystals. Quartz is only present in small amounts, equal to that of the ferromagnesian minerals, and consequently on the weathered surface the feldspars stand out and give the rock a texture reminiscent of rice pudding. This distinguishes the rock from the others in the area. In thin section the subidiomorphic character and uniform size of the feldspar (microcline and plagioclase) crystals are apparent as is the interstitial (to the feldspars) setting of the other minerals, namely very pale to medium green hornblende, quartz, pale to medium green biotite, pale to medium green chlorite replacing biotite, and accessory sphene, zircon, pistacite, magnetite, and hematite. Some of the hornblende shows incipient alteration to a mustard yellow mineral, probably serpentine.

The texture, composition, and regional setting of the 'south porphyritic granodiorite' and the 'rice pudding granodiorite' indicate that they may be genetically related. The porphyritic granodiorite may be a later stage differentiate of the magma which produced the 'rice pudding granodiorite', since the porphyritic granodiorite has a greater silica, potash, and water content.

Red-Brown Quartz Monzonite

In the southwestern part of Hembruff Township there is a local occurrence of deep red-brown granitic rock which may be more extensive in adjacent townships. This red-brown quartz monzonite may be genetically related to the two granodiorites. Minerals in the rock are: quartz, microcline, plagioclase, chlorite, pistacite, magnetite, and serpentine. The last four minerals are probably alteration products of hornblende.

Fine-grained Granite

The fine-grained red leucogranite which appears to cut the porphyritic granite in the northwestern part of Viel Township is similar to the fine-grained red granite elsewhere in the map-area. The rock is equigranular hypidiomorphic and consists of quartz, microcline, plagioclase, muscovite, chlorite after biotite, and accessory zircon and magnetite.

White Quartz Monzonite

In the northeastern extremity of Piche Township there is a white equigranular muscovite-biotite 'granite' with micaceous pegmatite. The fine-grained rock contains quartz, plagioclase (oligoclase-andesine), microcline (with inclusions, especially of quartz), muscovite, chlorite (after biotite), pistacite, and magnetite. This rock is hypidiomorphic granular. The pegmatite contains microperthite, quartz, muscovite garnet, and tourmaline. The quartz monzonite may be younger than most of the other intrusive granitic rocks. It is set apart by its white colour and the garnet and tourmaline in the associated pegmatite.

Age Relations and Petrogenesis of the Granitic Rocks

Age relations of some of the granitic rock types cannot be accurately determined, since the age of most of the rocks can only be ascertained relative to the migmatitic quartz monzonite. Thus it can be said that the porphyritic granodiorite in the northwestern part of Viel Township is younger than the migmatitic quartz monzonite. In turn, the fine-grained red leucogranite in the northwestern part of Viel Township is younger than the porphyritic granodiorite. However the age relationships between the fine-grained leucogranite in the northwestern part of Viel Township and the fine-grained red leucogranites elsewhere in the area are not known.

The porphyritic granodiorite in the southern part of the area may be the same age as that in the northwestern part of the area, but there is no indication of physical contact. It is not possible to relate the time of intrusion of the white muscovite-biotite quartz monzonite in the northeastern part of Piche Township to that of any of the other granitic rocks.

Results of absolute age determinations made on Archean granitic rocks within a 50-mile radius of Blind River indicate ages that range from 2,400 m.y. to 2,700 m.y. (Wanless *et al.* 1965; Van Schmus 1965). There seems to have been little system to the collection of these rocks. A systematic scheme of rock sampling where the granitic rocks have been mapped carefully might help to unravel the history of intrusion during the 'Kenoran Orogeny'. Evidence in the Rawhide Lake map-area indicates distinct periods of granite intrusion characterized by different granitic rock types.

The degree of metamorphism of the pre-granitic rocks was insufficient to cause partial melting of these rocks, even of the quartzofeldspathic sedimentary rocks, so that the granitic material must have come from an 'outside' source. Whether this granitic material was a result of deep-seated metamorphism of other sedimentary and igneous rocks, 'primary' magma, or regenerated granite is not known. Apart from the migmatitic phase, it is probable that all the granitic rocks were emplaced as granitic magmatic material. The quartz diorite was intruded first and has a fabric which suggests that it was syntectonic. Since there is no way of proving whether the inclusions in the quartz diorite were metamorphosed before intrusion, no definite statement can be made regarding relative ages of metamorphism and deformation of the Archean volcanic and sedimentary rocks and intrusion of the

quartz diorite. It is possible that this intrusion is significantly older than subsequent ones because some metadiabase dikes which cut the quartz diorite do not cut the other granitic rocks. A green coloration, altered appearance, and rather indistinct contacts are typical of these dikes. It is possible that the quartz diorite was intruded during a pre-Kenoran orogeny.

All of the red granitic rocks are probably genetically related, the more mafic types being intruded first. The red leucogranite is probably the last phase of this sequence of intrusion. The white quartz monzonite in the northern part of Piche Township may be much younger than the other granitic rocks; its associated pegmatite with 'exotic' minerals (garnet and tourmaline) could be an indication of its youth.

Inclusions in the Granitic Rocks

Inclusions of Archean volcanic and sedimentary rocks occur in the quartz diorite and the migmatitic quartz monzonite. The length of an inclusion may vary from a few inches to greater than 2 miles (3 km). The width is generally much less than the length. This can be seen west of Bass Lake, Viel Township. Some inclusions appear to be 'floating' in granitic material and may be pieced together to form larger entities.

These inclusions are all metamorphosed and possess a distinct vertical to steeply dipping schistosity which parallels a northwest regional trend. They can be divided into two distinct types, amphibolitic inclusions and quartzofeldspathic inclusions. They were found to be cut by numerous veins of granitic rock (Photo 3).

Some of the inclusions are biotitic and usually the smaller the inclusion, the more biotitic it is. A zonation may also be present; an inclusion may have an amphibolitic core with white andesine crystals, a zone of amphibole with pink and white feldspar (microcline and oligoclase) containing amphibole inclusions, and another zone of biotite with pink and white feldspars (microcline and oligoclase) which grades into granitic material.

The amphibolitic inclusions are thought to have originally been basaltic inclusions and the quartzofeldspathic inclusions either arenaceous sedimentary rocks or rhyolitic volcanic rocks. The zonation of amphibolitic inclusions would appear to be the result of reaction between hydrous granitic magma and mafic rock. Thus the more hydrated mineral, biotite, is found at the periphery of inclusions. The feldspar compositions in all parts except the core are that of the enclosing granitic rock (Pinsent 1968).

The presence of a distinct schistosity in almost all of the inclusions suggests that the inclusions must have possessed that schistosity prior to the intrusion of the enclosing granitic material. The intrusion of granitic stringers generally occurred parallel to the schistosity. Because the migmatitic quartz monzonite has no structural fabric, it is highly improbable that the intrusive granitic magma caused the schistosity. The absolute time relation of the metamorphism and deformation relative to granitic intrusion cannot be determined, but it would appear that the maximum intensity of metamorphism and deformation had passed before granitic intrusion occurred. There may even have been a long interval between the two events.

Middle Precambrian (Proterozoic)

POST-GRANITE—PRE-HURONIAN INTRUSIONS

There are at least three generations of mafic intrusions which postdate the granitic rocks. The first generation cuts only the Archean rocks and most of the mafic intrusions in the basement rocks belong to this generation. Intrusions of the second generation are equivalent to the Nipissing-type intrusions and are represented in the map-area by east-west striking sills, and a northeast-trending dike in the northwestern part of Viel Township; some of the smaller dikes cutting Archean rocks may also belong to this generation. The third generation is equivalent to the Sudbury swarm of Keweenawan age (Fahrig *et al.* 1965) and are the northwest-trending dikes which transect all other bedrock units in the map-area. Since the second and third generations are indubitably post-Huronian, they are discussed in the section on 'Post-Huronian Intrusions' later in the text.

The first generation intrusions are too small to show any compositional variation. They are quartz diabases. Contacts with the granitic rocks are sharp and margins of the dikes are chilled, suggesting that the granitic rocks were thoroughly cooled and solidified before the dikes were emplaced. These dikes have not been dated by radiometric techniques. They are unconformably overlain by Cobalt Group sedimentary rocks. Their relationship to other Huronian groups, especially the Elliott Lake Group, is not known. There are mafic volcanic rocks assigned to the Huronian Supergroup near Sault Ste. Marie (Frarey 1967; Hay 1963), near Massey (Robertson 1970, personal observation), near Agnew Lake (Card, personal communication), and at Dollyberry Lake (Robertson 1969). The original extent of these volcanic rocks is unkown. They may have been over most of the area of the present Huronian outcrop and the present distribution may simply be erosional remnants. It is reasonable to suppose that some dike-like feeders must have existed at the time of volcanism and that these dikes must have formed later than the granites and before deposition of the greater part of the Huronian succession. If the volcanic rocks are remnants of formerly extensive lavas, then many such dikes might be expected. These dikes under discussion may, therefore, be the same age as strata lower in the Huronian sequence. However since this has not been confirmed and since the term 'Huronian' has a supergroup connotation in this report, the dikes have been classified as 'pre-Huronian'.

HURONIAN SUPERGROUP

The term 'Huronian' as first used on the earliest geological map of Canada (Logan and Hunt 1855) included not only the Early Proterozoic rocks of Ontario but also Precambrian rocks in Michigan and the Thunder Bay and Keweenawan areas. Since that time usage of the word has varied and opinions as to its use are still quite divergent. The definition of 'Huronian' used in this report is that of the Federal-Provincial Committee on Huronian Stratigraphy (Robertson *et al.* 1969, p.12), which defines the Huronian Supergroup as 'that assemblage of sedimentary

and volcanic rocks occurring in the vicinity of the North Shore of Lake Huron, Cobalt, Sudbury, and adjacent areas and lying with marked unconformity on the Archean and intruded by the Nipissing Diabase'.

In most Precambrian terrains the only basis for positive correlation of rocks in two different areas is continuity of outcrop, since fossils are virtually absent. Neither lithological similarities nor isotopic age determinations are infallible criteria for correlation.

The relatively unmetamorphosed sedimentary rocks north of the Flack Lake Fault are considered to be Huronian and are assigned to the Gowganda, Lorrain, Gordon Lake, and Bar River Formations of the Cobalt Group. The sedimentary rocks rest unconformably on granitic rocks dated at 2,400 m.y. to 2,600 m.y. (Van Schmus 1965; Stockwell 1964) and are intruded by Nipissing-type diabase sills, one of which has been dated at 2,130 m.y. ±215 m.y. (Hofmann 1967). The rocks, thus, fit the definition of Huronian given by Robertson *et al.* (1969).

Although physical continuity with the original Huronian of the Sault Ste. Marie-Blind River area cannot be demonstrated, the occurrence of a homotaxial succession including 'exotic' rock types such as tillites suggests that the sedimentary rocks north of the Flack Lake Fault can be correlated with those of the original Huronian district.

Gowganda Formation

The Gowganda Formation lies unconformably on Archean granitic, metavolcanic, and metasedimentary rocks. It occurs only locally and fills valleys in the pre-Huronian land surface. Maximum exposed thickness of sediments in the western occurrence, north of McElrea Lake is around 530 feet (160 m); in the central occurrence southwest of Bilton Lake, 200 feet (60 m); and in the eastern occurrence west of Campover Lake, about 430 feet (130 m).

Rock types are: (map symbols in brackets)

- Massive and laminated arkose (6a)
- Graded lithic subarkosic wacke, mudstone, varved mudstone (6b)
- Paraconglomerate with a lithic subarkosic wacke matrix (6c)
- Polymictic orthoconglomerate with a lithic subarkose matrix (6d)

Orthoconglomerate

The basal member in each locality is an orthoconglomerate characterized by large cobbles and boulders which may be greater than 6 feet (2 m) in diameter (Photo 5). Although most of these are granitic, nearly all rock types, including vein quartz, found in the Archean rock exposures are represented. The high percentage of clasts of vein quartz is surprising considering the paucity of vein quartz in the area mapped. Since the area just north of the map-area has not been mapped, the extent of some of the basement rock types is not known. Many of the clasts in this particular orthoconglomerate seem to have been locally derived. Some of the clasts, especially the larger ones, are angular. If they were water-laid, they could not have

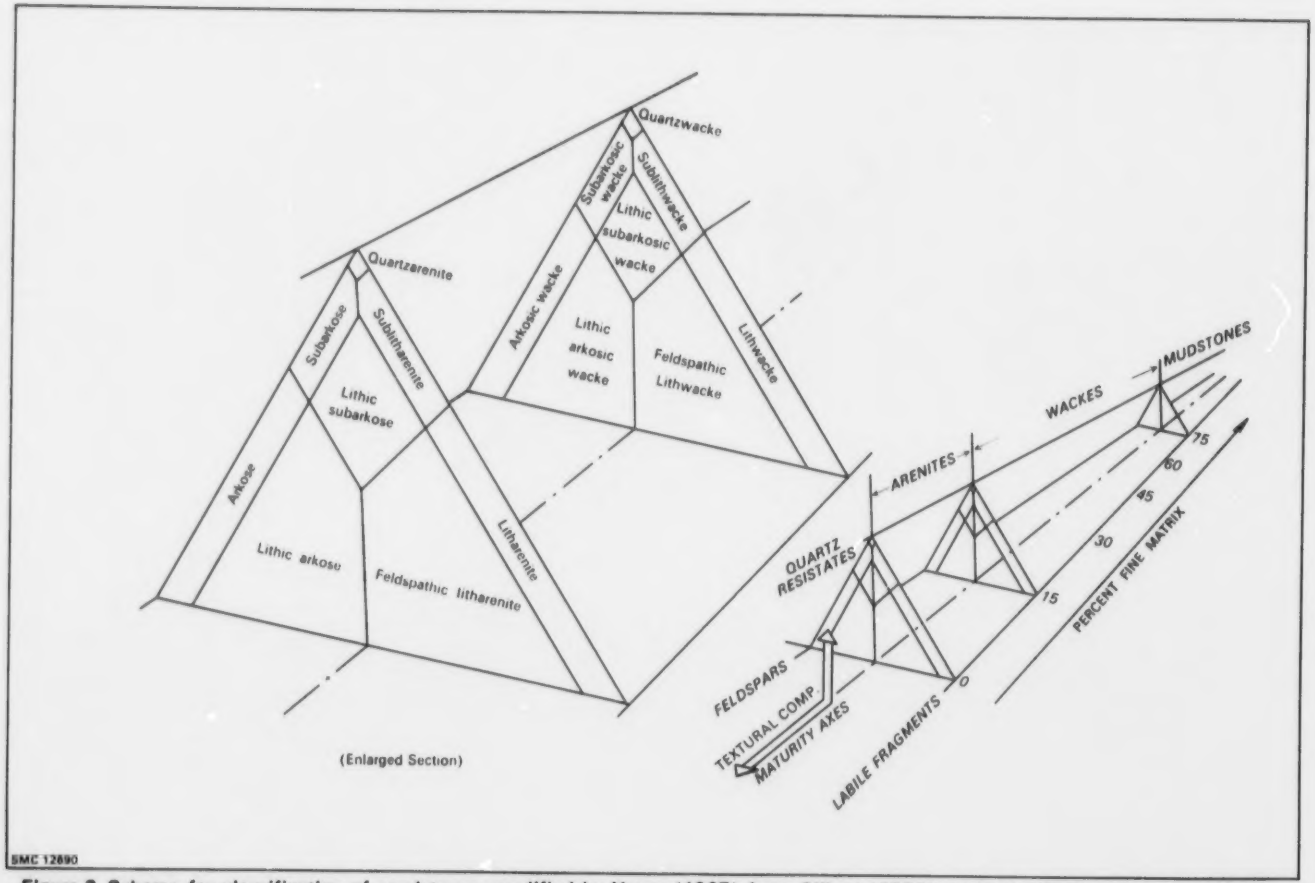

Figure 2–Scheme for classification of sandstones, modified by Young (1967) from Gilbert (1954), McBride (1963), and Dott (1964).

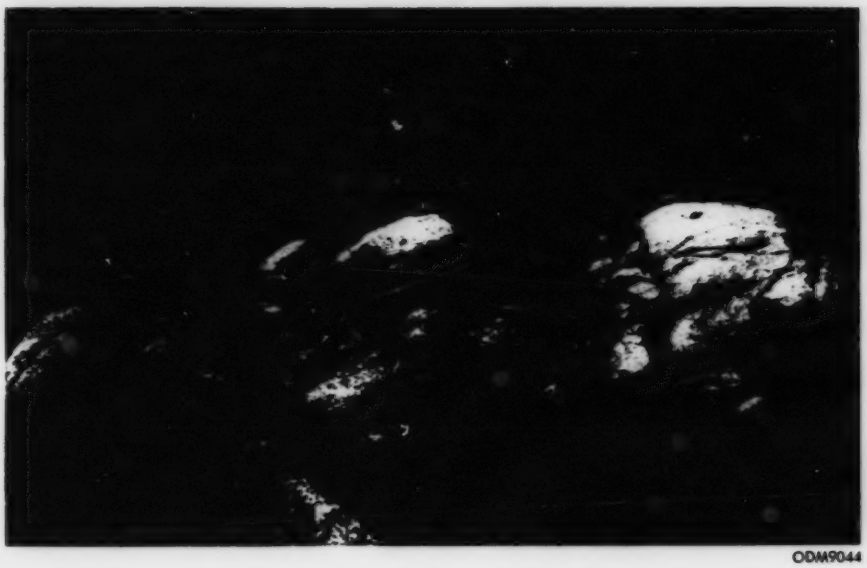

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Photo 5–Basal orthoconglomerate, Gowganda Formation, northwest part of Viel Township. Boulders and pebbles are of vastly differing sizes and shapes.

been transported far. There is no sign of weathering of these grantitic clasts nor is there any suggestion of a regolith on the granitic rocks underlying the Gowganda sedimentary rocks. In places where it is readily visible, the contact between Archean and Huronian rocks is very sharp. Cracks in the granitic rocks are filled with fine-grained detritus. In some places where arkose overlies granitic rocks, it is difficult to precisely delineate the contact.

The matrix of the orthoconglomerate is well indurated and has unweathered constituents. It is a lithic subarkose and is characterized by fresh feldspar crystals, some of which are euhedral. The matrix has a high chlorite content. In thin section the unsorted nature of the matrix is apparent. The grain size varies from 5 cm to submicroscopic, although most of the grains are sand-size being between 0.2 mm and 1.00 mm in diameter. The larger grains are invariably rock fragments with granitic clasts being most common. Mineralogically, the rock is similar to a granitic basement rock. Quartz, sodic plagioclase, and microcline are the most important minerals. Chlorite, muscovite, magnetite, hematite, zircon, and rock fragments constitute the remainder of the rock. Roundness which was measured on quartz grains is estimated at about 0.25 and sphericity is estimated at 0.69.

Paraconglomerate

In the northwestern part of the western occurrence of the Gowganda Formation, the orthoconglomerate grades into a paraconglomerate. In the paraconglomerate

the boulders are smaller in size and fewer in number; the proportion of granitic boulders is greater and the matrix is finer grained than in the underlying orthoconglomerate. Cobbles and pebbles are still plentiful. The predominantly pink and grey clasts are much larger than the clasts in the matrix. The matrix is characteristically poorly sorted and roundness of the grains is generally poor. This matrix is typically dark to light grey. The paraconglomerate is tough and brittle and breaks with a conchoidal fracture.

In thin section it is apparent that there is a marked contrast between the matrix of the paraconglomerate and the matrix of the underlying orthoconglomerate. Whereas most of the mineral grains in the orthoconglomerate matrix are sand to coarse silt in size with some clay-size materials, the paraconglomerate matrix has a complete gradation in grain size. Measurements of quartz grains in thin sections of the paraconglomerate matrix showed a gradation from 1.46 mm to less than 0.03 mm. Many of the sericite crystals are smaller than 0.03 mm. The rock matrix is poorly sorted.

All the pebble-size rock fragments visible in thin section are granitic, but sand-size grains of volcanic material and muscovite schist are present. The more abundant minerals are quartz, muscovite, and sodic plagioclase. Magnetite, clastic hematite, and chlorite are also present in lesser amounts. Other minerals are: muscovite, calcite as an alteration product, zircon, sericite, hornblende, sphene, epidote as an alteration product, and hematite as an alteration product. There may be several different varieties of clay minerals in the clay-size group of particles, but these do not lend themselves to optical identification.

The rock matrix is a lithic subarkosic wacke.

Graded Subarkosic Wacke and Mudstone

Above the paraconglomerate and associated with it are beds of wacke grading into argillite, i.e. indurated mudstones. In hand specimen the wacke parts of the beds are dark grey and argillaceous parts deep brown. Gradations in grain size are visible in hand specimen. The wacke parts of beds are usually characterized by concentrations of heavy minerals, especially magnetite.

Subarkosic wacke and mudstone are not abundant in the area mapped. They are intimately associated with the paraconglomerate and would seem to be a transitional stage between the paraconglomerate and the finely bedded argillite which seems to form the upper part of this particular tripartite sequence. This varved argillite constitutes only a minor part of the sequence.

The wacke units and the argillite units have a disrupted framework. Each wacke and argillite couplet represents a single sedimentation unit.

Some of the quartz grains have an estimated sphericity of 0.50 and an estimated roundness of less than 0.20. The mineralogy can be determined most readily in the coarser layers. Quartz, chlorite, albitic plagioclase, microcline, partially altered biotite, magnetite, hematite, and zircon are present with lesser amounts of muscovite, amphibole, and sphene. Small amounts of sericite, carbonate (probably calcite), and epidote are present as replacement products of feldspar; serpentine replaces amphibole and chlorite replaces biotite. Most of the feldspar grains are fresh and

unaltered. It, therefore, seems reasonable to suggest that the alteration visible in some feldspars occurred before rather than after deposition.

The grading is most apparent in the finer grained units. The coarser grained units, although also graded, are poorly sorted. In the fine layers sizes of quartz grains range from 0.04 mm to submicroscopic. Even in the fine-grained layers fresh grains of feldspar (0.01 mm in diameter) are present.

An estimate of size distributions and mineral composition places the coarse layers in the lithic subarkosic wacke class. The lower basal parts of the graded fine-grained units are in the same class, but the upper parts are in the lithic subarkosic mudstone class.

Because of poor outcrop and faulting, the detailed stratigraphic relations of the rocks in different outcrops are not known.

Arkose

North of the east end of McElrea Lake an arkosic orthoconglomerate with large clasts less than 5 inches (12 cm) in diameter lies directly on Archean basement rocks. This is overlain by and in places is interbedded with a paraconglomerate with pebbles dispersed in a dark grey lithic arkosic wacke matrix. Northeast of the east end of McElrea Lake an outcrop of orthoconglomerate lies near the Gowganda-Lorrain contact. Graded arenaceous and argillaceous material is associated with these conglomerates. Above this is an arkose unit which is mostly massive; however part of this unit has very thin graded bedding with the bedding varying in thickness but usually less than 1 cm. Pebbles up to 1 inch (2 cm to 3 cm) in diameter are found in the massive part and dropped stones up to 2 inches (5 cm) in diameter are found in the finely laminated part. In the massive part the rock could easily be mistaken for a granite inasmuch as the pebbles which are mostly pink and granitic are sparsely distributed and difficult to see because their coloration is similar to that of the host rock. Like other Gowganda rocks, this unit is indurated and breaks across the clasts.

In thin section the massive arkose shows some suggestion of bedding in the form of a weak quartz grain orientation. Most of the mineral grains are unaltered, but some feldspar grains have a thick sericitic coating. Sorting is poor but better than in any of the other Gowganda rocks. The largest quartz grains are about 1.44 mm in diameter and the smallest about 0.016 mm. The matrix is sericitic, fine grained, and similar to that in the overlying Lorrain Formation. This matrix material, together with quartz and other material less than 0.02 mm in diameter does not exceed 15 percent of the total rock. Roundness value of the larger grains is estimated at 0.25, whereas the sphericity is estimated at 0.78. The most important minerals are quartz, microcline, and sodic plagioclase. Other clastic grains are: muscovite, chlorite with some biotite remnants, chlorite schist which may possibly be metavolcanic, andesitic fragments, magnetite, hematite, metagreywacke, and muscovite-chlorite schist which was probably originally sedimentary. The rock is a lithic subarkose.

Some welding of the quartz grains has occurred with incorporation of matrix materials.

In the central part of the area only an orthoconglomerate with arkosic matrix is exposed.

The sequence in the eastern occurrence is similar to that in the western occurrence. A basal orthoconglomerate is present. Clasts are mostly granitic and range in diameter from around 3 feet (1 m) down to pebble-size; the matrix is arkosic. Away from the contact the matrix is dark coloured and a lithic subarkosic wacke. The clasts are smaller in size and less dense so that the orthoconglomerate gives way to a paraconglomerate. Graded wacke beds are associated with the paraconglomerate. The graded beds are overlain by arkosic rocks similar to those found in the western occurrence. An argillite is thought to occur above these, inasmuch as argillite fragments are found in a scree below the purplish red subarkose which the author considers the base of the Lorrain Formation.

It would, therefore, appear that within the map-area there may be one complete cycle and one incomplete cycle as follows:

argillite (?)
arkose
.....
argillite and wacke
paraconglomerate
orthoconglomerate

Lorrain Formation

The Lorrain Formation apparently conformably overlies the Gowganda Formation. In the eastern part of the area near Campover Lake clasts of Gowganda argillite are in the lower subarkose of the Lorrain Formation, but scouring could account for this occurrence.

Where the Gowganda Formation is not present the Lorrain Formation lies unconformably on the Archean basement.

Rock types: (map codes in brackets)

Quartz arenite (7a)
Quartz wacke and interbedded quartz and jasper pebble conglomerate (7b)
Hematitic conglomerate and arkosic rocks (7c)
Arkose (7d and 7e)
Subarkose (7f)

LOWER LORRAIN FORMATION

The lowermost subarkosic member is made up of well bedded fine-grained purple-red arenites. Although the base is usually scree-covered, the maximum thickness of the unit is estimated to be 53 feet (16 m); the maximum exposed thickness is 21 feet (6.5 m).

Quartz, microcline, and sodic plagioclase ranging in size from 0.72 mm down to 0.35 mm, and with a sphericity of 0.75, together with muscovite form the bulk of the rock. Some of the microcline and albite grains are partly altered; others are

fresh. The presence of a fresh grain adjacent to an altered one suggests that either alteration in the sedimentary rock was selective or that alteration had affected some grains prior to their incorporation in the sediment. The altered clasts have higher sphericity and roundness than the unaltered ones even though their edges may be rather ragged looking. Conditions of deposition were probably rather turbulent, inasmuch as some grains show imbrication. Grains of magnetite and hematite, varying widely in size, constitute an important part of the rock and are responsible for its purplish red colour; these grains appear to be detrital rather than chemical. Other minerals present are pyrophyllite, chlorite, epidote, and zircon.

The micaceous minerals accentuate the good bedding and are responsible for the rock's fissility. No crossbeds were noted in this part of the stratigraphic section, but they are present in overlying beds. The red arkosic rock varies from a coarse silt to fine sand. The total matrix is approximately 15 percent; therefore the rock is considered to be between a subarkose and subarkosic wacke.

This unit is overlain by 17 feet (5 m) of alternating red and green arkosic beds with individual beds being about 1½ feet (50 cm) thick. These in turn are overlain by approximately 20 feet (6 m) of thinner, about 5 inches (12 cm), alternating red and green beds.

These red and green beds grade upward into a coarser more massive green pebbly arkose which has some trough crossbedding. Pebbles, mostly of quartz but also of granite, have a maximum diameter of 0.6 inches (1.5 cm). Pebble bands may be up to 3.3 inches (8 cm) thick. Individual feldspar crystals are as much as 0.4 inches (1 cm) in length. At the base of the unit, the feldspars are fresh, pink, display cleavage and Carlsbad twinning, and may be subidiomorphic. Higher in the sequence, the feldspar crystals lack distinct cleavages and higher still the crystal outlines are diffuse. A subtle colour change also takes place from green to cream. Three hundred and fifteen feet (96 m) from the base of the formation there are thin green shaly horizons which are usually less than 2 cm thick.

Rocks of the upper part of the arkosic unit are exposed at the east end of Rottier Lake, northwest of the northwest arm of Rawhide Lake, along the north shore of Rawhide Lake near Rosemarie Lake, and southwest of Campover Lake. They differ from rocks of the lower part in that they contain less feldspar, show distinct bedding, and have coarse pebbly sandstone beds which are deep purple-brown. Pebbles up to 1 cm in length are invariably of quartz. The purple-brown colour is derived from heavy minerals with the most abundant being hematite. Grain size varies from fine sand to small pebble-size with the fine sand layers having a maximum thickness of 12 cm. Some coarse layers are more than 10 feet (3 m) thick. Toward the top of this arkosic member, there are virtually no recognizable feldspar crystals and the matrix is white and similar to that of the white quartz wacke and quartz and jasper pebble conglomerate of the middle part of the Lorrain Formation. This upper part of the arkosic member is about 200 feet (60 m) thick. Grains of hematite are scattered through the lower arkosic section, but the main concentrations of hematite and other heavy minerals occur in the upper part of the arkosic member and in the lower part of the overlying quartz wacke-conglomerate section.

From thin sections, it can be seen that in some of the coarser beds near the bottom of the member, the grain size of detrital quartz and feldspar grains range from approximately 3.5 mm to 0.054 mm. Average sphericity values are greater

than 0.79 and roundness is commonly about 0.40. Estimates for a rock at the top of this arkosic sequence are:

sphericity – 0.79 roundness – 0.4 to 0.45 maximum grain size – 2.16 mm minimum grain size – 0.088mm	measured on detrital quartz grains

The sphericity and roundness are therefore similar but the sorting is slightly better in the sample from higher in the sequence.

The dominant minerals in the lower part of the member are quartz and microcline. Other minerals are sodic plagioclase, muscovite, hematite, magnetite, zircon, pyrophyllite, kaolinite, and chert. The hematite and magnetite grains are associated with zircons and all are probably detrital. The hematite grains have overgrowths and appear as skeletal crystals arranged in a trigonal pattern. Some of the feldspar crystals are relatively fresh. Others are partially altered. The rock has an intact framework.

The mineralogy of the overlying 46 feet (14 m) of sedimentary rock is similar to that of the beds described above, except that the feldspars show a greater degree of alteration with an accompanying slight increase in volume of the matrix. The framework of the rock is still intact. The next 59 feet (18 m) show more marked changes. Some clasts appear to be 'floating' in the matrix, but the framework is probably intact and feldspars are still plentiful. Four hundred and thirty-three feet (132 m) above the base of the unit there are few feldspar grains and remnants of original feldspar grains are enclosed by kaolinite, sericite, and pyrophyllite. Also distributed throughout the rocks (as seen in thin sections) there are discrete areas of these three minerals, which may represent the post-depositional alteration products of feldspar grains. Also notable in these areas are small blobs of quartz. These may represent the excess silica from the reaction:

$$\text{feldspar} + \text{water} = \text{kaolinite} + \text{potash} + \text{soda} + \text{silica}$$

If these textures have been correctly interpreted, the original mineralogy of these rocks was similar to the mineralogy of the rocks at the base of the arkosic member. Four modal analyses are given in Table 2. The first is of a rock at the base of the member, the second of a sample from the middle of the member, and the third of a rock at the top of the member. The fourth modal analysis is from

Table 2 MODAL ANALYSES OF SPECIMENS FROM THE ARKOSIC MEMBER OF THE LOWER LORRAIN FORMATION (IN PERCENT)

Sample No.	Quartz	Feldspar	Matrix	Accessories
3887	53	29	15	3
W-67-40	49	13	38	0
W-67-46[a]	56.5	0	43.5	0
W-67-46[b]	56.5	27	16.5	0

[a]Uncorrected modal analysis.
[b]Same analysis but with patches of matrix counted as feldspar.

the same rock as the third but with patches of alteration products counted as feldspar. Modes one and four show a close similarity indicating that mineralogy may have originally been similar. Stages in the feldspar decomposition are shown in Photos 6, 7, 8, and 9.

The final result of this feldspar decomposition, the appearance of diaspore, occurs 100 feet (30 m) above the last described rock. The rocks containing diaspore are texturally quite similar to the underlying rocks, but roundness and sphericity values are slightly higher. The roundness and sphericity of the larger grains are higher than those of small grains; large grains have an estimated roundness of 0.5 and sphericity greater than 0.83, whereas roundness of smaller grains is around 0.35 and sphericity around 0.68. These rocks may be considered bimodal.

Quartz is more abundant than any other mineral. Most grains are single crystals and, therefore, presumably igneous or vein quartz, but some are polycrystalline and may have originated from pre-existing quartzites or may be pegmatitic quartz, as opposed to igneous quartz from medium-grained granitic rocks. Silt- and clay-size hematite grains are present. Sericite and kaolinite are both present, but 'books', 'worms', radial aggregates, and randomly oriented crystals of pyrophyllite appear to constitute the bulk of the interstitial material.

Diaspore occurs as idioblastic crystals in areas between quartz grains and some crystals are greater than 5 mm in length.

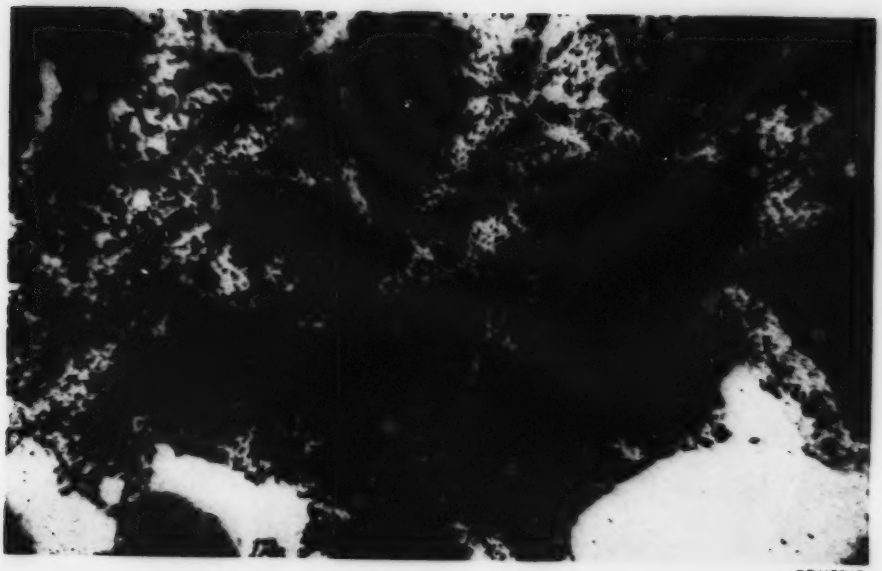
In most of the upper arkosic arenites there is apparent incorporation of matrix into quartz clasts.

MIDDLE LORRAIN FORMATION

The middle Lorrain conglomerate-quartz wacke member occurs south of a line through Rottier, Rawhide, and Rosemarie Lakes. The quartz wacke is medium grained and white to off-white. White powdery clay minerals are usually present. Crossbedding near the base of the unit is accentuated by concentrations of dark heavy minerals. Bedding is not everywhere conspicuous, but regional dips can be obtained from the abundant conglomerate beds (Photo 10). Stratigraphic separation of conglomerate beds varies from a few centimeters to tens of metres. Conglomerate beds range in thickness from about 2½ inches (6 cm) to about 20 feet to 23 feet (6 m to 7 m). The lower beds are rich in hematite. The hematitic conglomerate and underlying hematitic arkose are radioactive to about two or three times background. The radioactive minerals occur in the heavy mineral concentrations. The hematitic beds are quite friable. It is thought that radioactive bombardment from the uranium and thorium minerals may have caused disintegration of both the conglomerate matrix and the conglomerate pebbles. Alternatively the friability may be due to mechanical movements affecting this particular horizon, such as low angle shearing parallel to the bedding.

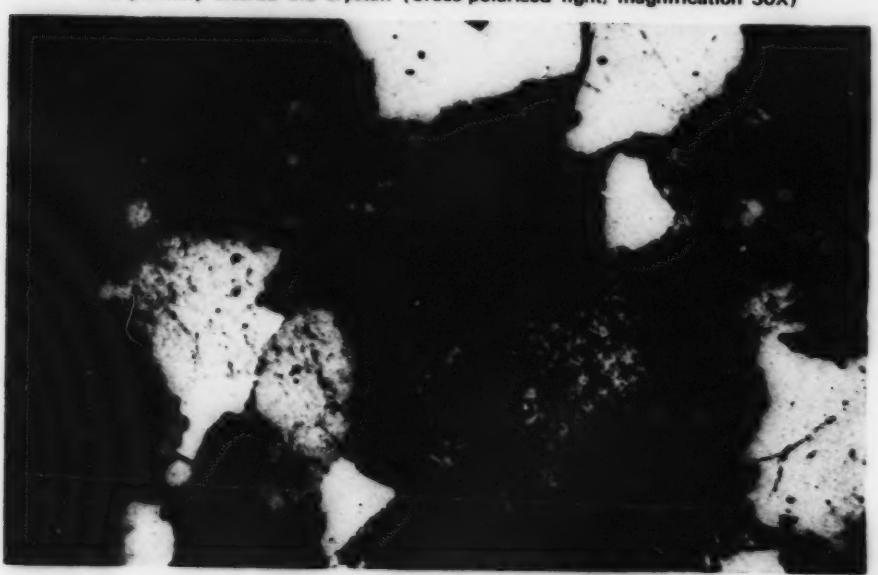
These radioactive rocks have attracted much attention as a potential source of uranium. However results have been disappointing since thorium minerals rather than uranium ones have been found responsible for the radioactivity (see 'Thorium and Uranium' in 'Economic Geology' section).

Pebbles in the conglomerate beds are quartz, jasper, chert, and some quartzite



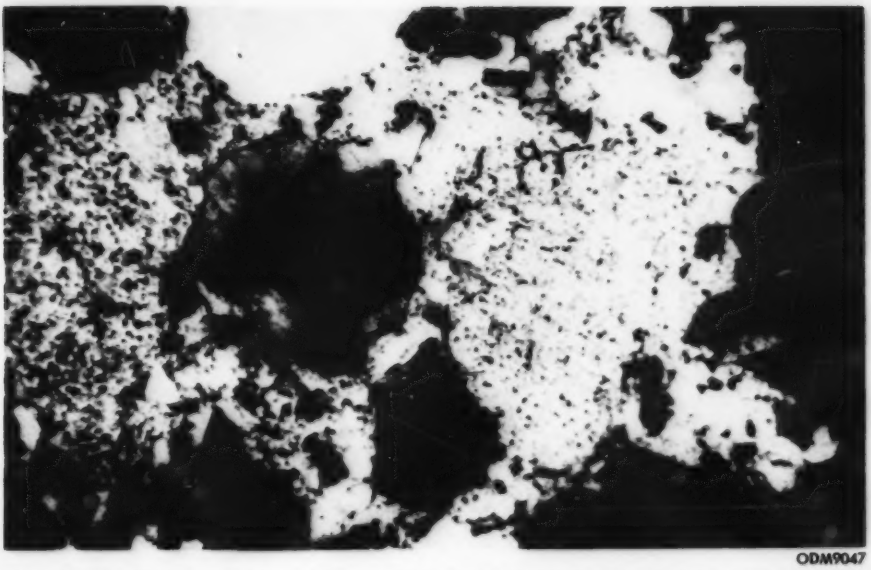
ODM9045

Photo 6–Photomicrograph of arkose, lower part of lower Lorrain Formation, McElrea Lake. The crystal, in extinction, in the central part of the photograph is feldspar. Alteration has partially altered the crystal. (Cross-polarized light, magnification 30X)



ODM9046

Photo 7–Photomicrograph of arkose, middle part of lower Lorrain Formation, McElrea Lake. Remnants of feldspar crystals are present in the middle of the photograph in an extinction position. (Cross-polarized light, magnification 30X)



ODM9047

Photo 8–Photomicrograph of rock from upper part of lower Lorrain Formation, Rottier Lake. No feldspar remains in the rock. The larger round areas of matrix are considered to have originally been feldspar crystals. (Cross-polarized light, magnification 30X)

ODM9048

Photo 9–Photomicrograph of diaspore in rock from upper lower, lower middle parts of Lorrain Formation. The diaspore is the dark grey mineral in the centre of the field of view. It is considered to have developed under tropical climatic conditions from the alteration of feldspar. (Cross-polarized light, magnification 30X)

ODM9049

Photo 10–Quartz and jasper pebble conglomerate, middle Lorrain Formation, Rawhide Lake. The red jasper pebbles show up black in the photograph.

and granite which is probably locally derived. Within the conglomerate beds there are heavy minerals which are in some places stratified or concentrated underneath pebbles and in other places distributed randomly throughout the matrix. South of Rawhide Lake in the middle of the conglomerate quartz wacke sequence, pebbles are as much as 4 inches (10 cm) in long dimension. Crossbedding is more common in the more arenaceous rocks of the upper part of the conglomerate-quartz wacke sequence. The upper conglomerate beds are better sorted than the basal ones; they are also more mature in that pebbles are composed only of silica and include vein quartz, quartzite, jasper, and chert, whereas the basal beds contain all of these as well as medium-grained granitic pebbles and pebbles of fine-grained aplite. Granite pebbles were identified on the headland across the lake from and to the southeast of McElrea's tourist outpost on Rawhide Lake; here conglomerate lies stratigraphically close to the Archean basement.

In the lower conglomerate beds the roundness and sphericity of the pebbles seem to vary according to the pebble size. The smaller pebbles, approximately 1 cm in diameter, have high roundness and sphericity values; roundness may exceed 0.75 and sphericity 0.90. Larger pebbles do not show high sphericity and roundness. Several pebbles, 1.5 cm to 3 cm in diameter, were extracted from the rock and roundness estimates averaged 0.43 and sphericity 0.70. Some pebbles are disc-shaped and lie parallel to the bedding. These occur together with spherical pebbles of similar composition so that the shape is apparently original and not tectonic.

No imbrication of such pebbles was noted, but imbrication may have been eliminated by compaction.

Higher in the sequence, the pebbles are better sorted and more uniform in shape. Average roundness is estimated at 0.55 and sphericity is usually greater than 0.73. Because the conglomerate is strongly indurated, pebbles are difficult to extract. The framework of the pebble conglomerate beds appears to be intact.

The thickest conglomerate bed seen was approximately 20 feet (6 m) thick and the thinnest was one pebble thick. Beds at the bottom of the sequence tend to be thicker than those higher up. The matrix of the conglomerate and the conglomerate interbeds are similar in both composition and texture. The clastic grains in the matrix vary from coarse to fine sand-size. The framework of the rocks differs from that of the upper part of the arkosic member in scarcity of matrix-filled areas. Minor fine-grained argillaceous beds are in the sequence.

In a thin section of the matrix from one of the hematitic conglomerate beds, the maximum grain size is 5.4 mm. There are several pebbles of this size and also many grains around 0.8 mm and 0.09 mm in diameter. There are three separate size modes in this one thin section. Sphericity and roundness decrease with decrease in grain size. The pebble-size clasts have an estimated roundness of 0.75 and sphericity of 0.89; the medium sand-size particles have an estimated roundness of 0.4 and sphericity of 0.80; the fine sand-size particles have an estimated roundness of 0.38 and a sphericity of 0.63. Thus the coarse sand-size grains have higher roundness and sphericity values than the fine sand-size grains. The composition of the grains in the rock also varies with size. Thus the pebble-size clasts are nearly all vein quartz and chert, whereas the sand-size grains are apparently nearly all igneous quartz. In a thin section of the matrix of the hematitic conglomerate bed, the rock components are quartz, banded chert, pyrophyllite (worm-like mostly), magnetite (?), hematite in sand- and silt-size particles, sericite, kaolinite, and some detrital muscovite. Quartz overgrowth and authigenic hematite are present. The chert grains contain submicroscopic crystals of hematite and laths (0.01 mm) of sericite; chert grains range in diameter from 0.001 mm to 0.06 mm.

Higher in the sequence, hematite is less common. In one thin section most of the grains are around 2 mm in diameter (some are granules) and the remainder are around 0.2 mm in diameter. The latter are probably as numerous as the larger ones but make up a smaller volume of the rock. Roundness of the course sand fraction is estimated at 0.30-0.35 and the fine sand fraction at slightly less. Sphericity values of both are around 0.75. Chert is the only other clastic component present except for some grains of hematite and muscovite. The ratio of matrix to clasts is high, but the framework is still intact and there is no evidence that the rock ever contained feldspar. The matrix is composed of pyrophyllite, kaolinite, and sericite.

The matrix of a conglomerate high in the section shows textural and mineralogical features similar to those found in the rock type just described from lower in the sequence. It has slightly poorer sorting and less true (less than 0.02 mm) matrix. As in the rock just described, most of the grains are apparently igneous quartz with some vein quartz, i.e., the larger grains, and chert. These rocks may be classified as quartz wacke.

The interbedded quartz wacke is texturally and mineralogically almost identical to the conglomerate matrices.

The conglomerate-quartz wacke member has a thickness of about 425 feet (130 m) and passes transitionally into the quartz arenite member of the formation.

ODM9050

Photo 11–Crossbedded quartz arenite, upper Lorrain Formation, Boland River Valley.

UPPER LORRAIN FORMATION

This quartz arenite member is fine grained and is composed of more than 90 percent quartz. It is white to off-white. In hand specimen, kaolinite is present interstitial to quartz. Crossbedding is abundant and the rock is equigranular (Photo 11). Tiny specks of chalcopyrite are present throughout the lower part of the member; this particular part has a thickness of 630 feet (190 m).

Above the lower part of the member, pebbles are again present in the rock. The majority of the pebbles are less than 0.4 inches (1 cm) in length, but some are around 0.8 inches (2 cm). Most of the pebbles are quartz. Conglomerate beds are less than 4 inches (10 cm) thick. Coincidental with the presence of the pebbles is a green coloration and farther up the section thin green argillite bands appear. The pebble conglomerate occurs over a stratigraphic thickness of 40 feet (12 m).

Several thin sections were cut from quartz arenite beds at different stratigraphic levels and one was cut from a pebbly quartz arenite bed. Apart from the presence of heavy minerals in the pebbly beds and a slightly higher matrix content, there was little difference between the various sections. Quartz is the predominant mineral and forms a tightly welded network with some small intergranular cavities containing pyrophyllite and kaolinite crystals. Quartz overgrowth on detrital grains cement the quartz grains together.

Rawhide Lake Area

Sorting and grain size varies in the different beds of the quartz arenite. All the quartz grains are sand-size except in the pebbly beds where clasts may reach 1 cm in diameter. These larger clasts are either quartz or chert. Zircons, some of which are exceptionally clear, are common and a few iron oxide grains are present. In thin section in plane polarized light, kaolinite, which can be recognized in hand specimen, can be seen to occur as a coating on the quartz grains.

This upper part of the Lorrain Formation is different from that in the Espanola-Whitefish Falls area (Card, personal communication). Above the white quartzite member which is similar to the white quartz arenite member in the area under study, Card reported a quartz arenite which resembles a chert because of the fine grain size and exceptional purity.

Above the pebbly part of the Lorrain Formation thin (4 inch; 10 cm) beds of quartz arenite are interbedded with green argillite. Upward in the section argillite beds become much more common and concentrations of heavy minerals appear in the quartz arenite units. Specks of chalcopyrite and pyrite are also visible and blebs (about 3 mm in diameter) of specular hematite are present. Both the specular hematite and pyrite have alteration zones around them. These quartzose rocks become impure and what appears to be feldspar can be seen. The thickness of this part of the sequence is about 360 feet (110 m). Argillite beds are significant in only the last 110 feet (33 m).

Since the quartzose arenaceous rocks are typical of the Lorrain Formation and the argillaceous rocks are typical of the Gordon Lake Formation, the boundary between the two formations is considered to be where the thickness of the quartzose rocks is considerably diminished and where the first laminated argillite exceeds 1 inch (2.5 cm) in thickness. The contact may be a disconformity. Approximately 130 feet (40 m) above the boundary, 'quartzites' are no longer present. The total thickness of the Lorrain Formation is approximately 1,800 feet (550 m).

Gordon Lake Formation

The Gordon Lake Formation as defined by M. J. Frarey (1967) is the equivalent of what for many years has been known as the 'Banded Cherty Quartzite'. This formation and the overlying Bar River Formation, which was formerly known as the 'Upper White Quartzite', have received little attention in the past. This is due to the former inaccessibility of most areas underlain by these rocks. For example, both the Flack Lake area and Killarney area have only recently been readily accessible. It is also due to their restricted areal distribution when compared to other Huronian Formations. Collins (1925), Harding (1939), Young (1966), and Casshyap (1967), mention these formations very briefly and Frarey (1967), who proposed the new formation names, described them in but a few words. Card (1968) and Robertson (1969a) have mapped the formations. G. H. Eisbacher and H. U. Bielenstein (1969) gave thicknesses for both formations from drill hole data north of the Flack Lake Fault and proposed a three-fold subdivision of the Gordon Lake Formation.

Rock types are not differentiated on the Geological Map (back pocket) because of lithological diversity.

LOWER AND MIDDLE GORDON LAKE FORMATION

The lower part of the Gordon Lake Formation is interbedded quartzose sandstone and argillite, 1 inch to 1½ inches (2.5 cm to 3.75 cm) thick. The sandstone beds have small-scale crossbedding and the basal part of each bed has a heavy mineral concentration, up to 5 mm thick, which decreases upwards. Argillite beds increase in number away from the base of the formation. These beds are dark grey-green, brown, and pale green, and range in thickness from 2 cm (0.8 inches) to less than 1 mm.

Intraformational breccia is first encountered 135 feet (41.0 m) above the base of the formation. Fragments vary in size and shape and are elongated. Although all the fragments have a length exceeding their thickness; their long dimensions are oriented parallel to the bedding. Many of the fragments are lenticular with rounded ends, whereas others have irregular shapes. At this stratigraphic level the formation is made up of argillite and siltstone with subordinate sandstone. Intraformational breccia is common. Breccia fragments are for the most part locally derived, but a few "exotic" fragments are present. Breccia layers of white cherty-looking fine-grained siliceous argillite in a brown or green argillaceous matrix are notable in this context. Where the breccia fragments are green argillite, pink to buff rims are common around the clasts.

Seventy-three feet (22 m) from the basal part of the formation, there are nodular aggregates of chert and anhydrite and gypsum. Anhydrite and gypsum nodules range in size from about 0.4 inches (1 cm) to 1 inch (2.5 cm). Some are more than 2 inches (5 cm) in diameter. The anhydrite and gypsum is bright orange and individual crystals are easily seen in hand specimen. When associated with chert, the chert is also orange and commonly forms the core of the nodules with the anhydrite or gypsum forming a thin rim. Average diameter of these cherty nodules is about 0.4 inches (1 cm).

In thin section the anhydrite and gypsum nodules can be seen to be composed of gypsum, anhydrite, and calcite. Crystals of anhydrite are anhedral and have no inclusions; the gypsum crystals are also anhedral but can be distinguished from the anhydrite by their very low birefringence; the gypsum crystals contain many acicular inclusions of anhydrite which commonly have a preferred orientation. Apart from a very thin margin of gypsum around the nodules, the arrangement of gypsum and anhydrite crystals is random. The calcite crystals are also sporadically distributed. The chert nodules have the same orange colour as the anhydrite and gypsum and many have a thin (1 mm to 2 mm) surrounding layer of coarser chert and gypsum. Like the anhydrite and gypsum nodules, the chert nodules are embedded in a subarkosic wacke matrix. The chert which forms the main core of the nodules is finely crystalline and pure except for some tiny specks of hematite and some calcite crystals. Thin sections from surface samples show that the halo surrounding the core of chert is also largely composed of chert but is much coarser grained than in the middle part of the nodule. There are solution cavities in the outer halo. Inspection by binocular microscope of fresh core samples from the hole drilled by Canadian Johns-Manville Company Limited near Flack Lake indicates that the cavities may represent anhydrite or gypsum crystals. Staining seen in thin section of weathered samples may be explained as resulting from the alteration of small hematite grains which were seen in fresh core samples.

Rawhide Lake Area

At the same stratigraphic level as the anhydrite and gypsum nodules, there are thin, less than 1¼ inches (3 cm), pink-brown sandstone layers which are feldspathic. These pink sandstone beds and the gypsum nodules are limited to a stratigraphic thickness of around 80 feet (25 m). The next 130 feet (40 m) are made up of green, brown, and some blue argillites and siltstones; intraformational breccia is present at several horizons and, in one part, some of the breccia may be tectonic in origin. Sandstone-siltstone intrusions appear in this part of the sequence. They are generally 3 mm to 5 mm thick and may be either dike-like or sill-like. They are very common higher in the succession.

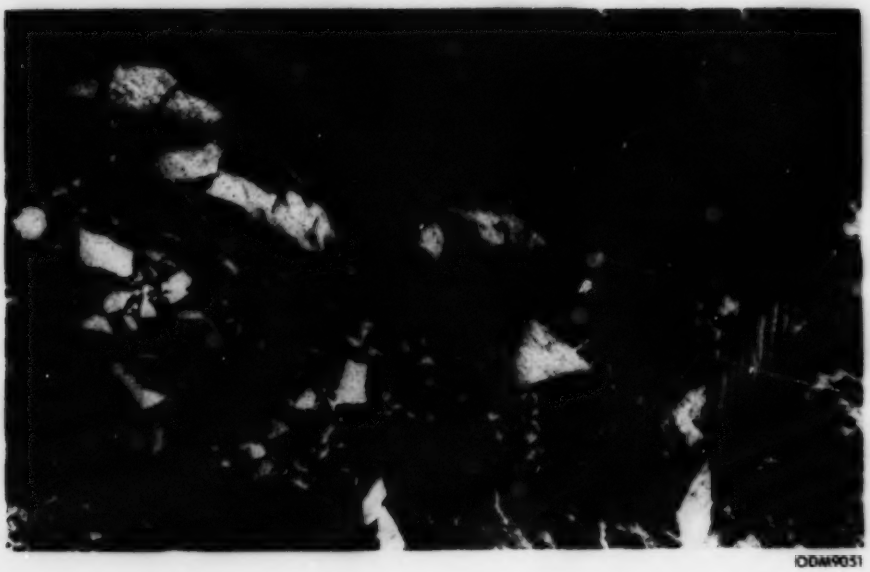
These rocks are overlain by about 130 feet (40 m) of various shades of green mudstone and siltstone. Some thin brown layers are also present. Much of the mudstone is exceedingly fine grained and previously has frequently been identified as chert. This is the rock type which led to this formation being described as 'cherty' (Collins 1925). Bedding may or may not be visible. In thin section it can be seen that disseminated flakes of muscovite and chlorite up to 0.054 mm in length have a parallel orientation. Quartz crystals are mostly about 0.006 mm in diameter, but some reach 0.03 mm in diameter. These larger crystals are distributed randomly through the finer grained material. Zircon, hematite, and tourmaline are also present. The presence of these heavy minerals, the mixture of different sizes of quartz grains, and the presence of oriented muscovite and chlorite crystals suggest that the rock is detrital. Because of the fine grain size, individual grain shapes cannot be determined in the main mass of the rock which is cemented by silica. The hardness of this rock is less than that of true chert. It is, therefore, concluded that the green rock type is not chert, but a very fine grained mudstone composed largely of detrital quartz of fine silt-size.

UPPER GORDON LAKE FORMATION

In the top 325 feet (98.8 m) of the formation arenaceous siltstone and shale are the most important rock types. Very close to the top some fine sandstone is present. Cream to mushroom coloured chert is more common in this part of the section than in any other.

The arenaceous siltstone (Photo 12) is subarkosic wacke and, except for a slight increase in the percentage of sand-size grains and hematite, is similar to that lower in the sequence. Thirty metres (100 ft.) from the top of the formation the sand-size grains are more abundant and larger (0.45 mm) than those seen elsewhere in the Gordon Lake Formation. Most are subangular to subrounded with roundness values from 0.30 to 0.40 and estimated sphericity values from 0.90 down to 0.60.

All the coarse grains are quartz, but fresh sodic plagioclase and microcline are present as coarse silt and very fine sand. Sericite is present in the matrix, but the bulk of the matrix is composed of very fine grained quartz. Sheaf-like aggregates of pyrophyllite similar to those found in the Lorrain Formation are also present. Sericite forms a ring on many of the quartz grains. Heavy minerals such as zircon and tourmaline are common. Hematite occurs as detrital grains but may also be authigenic.



ODM9051

Photo 12–Sandy siltstone showing slump structure, Gordon Lake Formation, Hembruff Township.

Near the top of the formation there are small-scale sedimentary intrusions. The rock type which hosts the sedimentary intrusions is almost identical to the previously described green mudstone which has so frequently been mistaken for chert, but this host rock has slightly larger grains and considerably more fine-grained hematite which gives the hand specimen its dark brown colour. The intruding material is a subarkosic wacke. Most of the feldspar is either sericitized or albitized with hematite exsolution. This is the first occurrence of altered feldspar noted in this formation. Hematite is abundant and forms at least 5 percent of the rock. Commonly, there is a colour change in the rock from brown to green near the contact with the intrusions. This colour change is also present although to a lesser degree, where a bed of sandstone adjoins a bed of brown argillite.

'Fossils' have been described from the overlying Bar River Formation by H. J. Hofmann (1967) and Young (1967a). These 'fossils', also, occur in the upper Gordon Lake Formation at the west side of Stag Lake. Young (1969) has recorded the occurrence in the Gordon Lake Formation of structures somewhat similar to those found in the Bar River Formation. He suggests that the structures are inorganic and formed as sedimentary intrusions.

Oolitic Subarkosic Wacke Breccia

A sample from the north-facing scarp, south of the Boland River, contains hematite ooliths (Photo 13) and an authigenic chlorite matrix. The clastic grains

ODM9052

Photo 13–Hematite oolith, Gordon Lake Formation, Boland River Valley. (Magnification 30X)

which constitute the bulk of the rock are quartz, sodic plagioclase, both fresh and altered grains of microcline, zircon, tourmaline, hematite, muscovite, and clay minerals. There are also pellets of apparently unoriented muscovite and/or sericite crystals and a colourless low-birefringent material, possibly chamosite. The pellets are about 0.15 mm in diameter. They are different from the other minerals seen in this formation.

There are other rock fragments, 2 cm to 2 mm in diameter, and similar in composition to the silstone shales seen in other points of the formation. In thin section all the smaller siltstone clasts are colourless, but the larger ones are brown in the middle with a thin, 1 mm to 1.5 mm colourless border. There is more intense colour at the inside edge of this border than anywhere else. Where a small arenite intrusion has penetrated a clast, the clast is colourless adjacent to the intrusion. This colour change is probably related to reduction of iron. In hand specimen these colourless areas are light green.

Bedding in the rock is rather indistinct and can be traced only by layered concentrations of heavy minerals. The hematite ooliths are not found with the heavy minerals.

The maximum length of the smallest clastic quartz and feldspar grains is approximately 0.03 mm. The most common grain size is about 0.15 mm so that the rock is an arenite. Both roundness and sphericity are low; estimated average roundness is 0.30; estimated average sphericity is 0.65.

The average diameter of the ooliths is 0.20 mm. Arrangements of the constituent

particles may be concentric or radial or both in any one oolith. Some of the ooliths are composed of structureless hematite and lack radial or concentric structures. Other ooliths are partly composed of hematite and partly of another mineral. The relief of this mineral is low; its birefringence is low; and it is colourless except for a few places where it shows a delicate shade of brown, caused presumably by very fine grained hematite. It is tentatively identified as greenalite. Some of the ooliths have a hematite grain as nucleus.

The most important matrix component of the oolitic rock is a medium green chlorite. Some sericite is also present but only in minor amounts. Where heavy minerals are present, sericite matrix is more important. Calcite is present throughout the rock.

Ripple-marks and mudcracks are abundant throughout the whole formation.

Outcrop of the Gordon Lake Formation is generally rather poor. That part of the sequence near the contact with the Bar River Formation is usually well exposed because of the resistance of the overlying quartzites. The Gordon Lake Formation is about 1,000 feet (300 m) thick in the map-area.

Bar River Formation

The Bar River Formation is a sequence of crossbedded quartz arenite and subarkose, and siltstone with ripple-marks and mudcracks. This formation was formerly known as the 'Upper White Quartzite' until Frarey (1967) renamed it. At the type locality east of Sault Ste. Marie, the approximate thickness is 1,000 feet (300 m). A diamond drill hole bored by Canadian Johns-Manville Company Limited near Flack Lake just west of the map-area indicated a thickness of approximately 1,000 feet (300 m). Another drill hole west of Flack Lake (Eisbacher and Bielenstein 1969) gave a thickness of 1,500 feet (450 m). In the Lake Panache area the formation exceeds 4,000 feet (1,200 m) in thickness (Frarey and Cannon 1968).

The contact between the Gordon Lake and the Bar River Formations is similar to that between the Lorrain and the Gordon Lake Formations, in that the change in rock composition is very abrupt.

The uppermost part of the Gordon Lake Formation is a buff feldspathic sandstone. This is overlain by a coarse-grained, white, feldspar-free, quartz arenite bed, typical of the Bar River Formation which also is lacking in feldspar. Above this horizon feldspar is not present except near the top of the formation. Some of the rocks, particularly the siltstones, are similar to those in the Gordon Lake Formation. The upper arenaceous parts of the Gordon Lake Formation as well as being feldspathic have clasts with low roundness and sphericity. In contrast, the quartz grains in the silica-cemented quartz arenite in the lowermost parts of the Bar River Formation have an estimated roundness of 0.60 and an estimated sphericity of 0.87, as measured on dust-train outlines.

STRATIGRAPHY

Seven feet (2 m) from the base of the Bar River Formation a granule bed occurs. The lower part of this bed has concentrations of hematite. Clasts are quartz and

jasper; some of the jasper is surficially altered to kaolin. The granule bed grades upward into a well sorted sandstone unit with rounded grains. The sandstone unit is similar to others in this formation in that there is only a small amount of matrix. Some parts of the sandstone unit are very friable. A quartz cement is present locally. There are variations in grain size and scattered mottled pink, brown, or black patches in the sandstone unit which is about 30 feet (9 m) thick.

The sandstone is overlain by a green and brown shale and siltstone sequence. Most of the lower part is green, but the distribution of colour is not related to the bedding. A dark irregular line separates grass green rock from yellow-green to brown rock. This colour change may be an oxidation-reduction phenomenon. Above this fine-grained multicoloured unit there are 3 cm of yellow siltstone-shale with some intraformational breccia. The overlying bed is brown. About 7 cm above the top of the yellow siltstone-shale unit very fine regular banding is present and consists of quartzose layers about 1 mm thick alternating with brown hematitic layers about 0.2 mm thick. This banding is similar to that found in Animikie-type iron formation. This unit is overlain by 13 feet (4 m) of brown and green banded siltstone. The next 13 feet (4 m) is composed of sandstone with shale partings at about 1 foot (30 cm) intervals. The sandstone is friable and white matrix material may be kaolinite. Shale partings are again of the brown-green banded variety.

The next 85 feet (25 m) is composed of friable sandstone in which some quartz grains show hematitic encrustations.

Overlying the sandstone are beds of brown and light green siltstone and shale. Some of the brown beds show what may be slump structures. Pale grey beds of shale are usually brecciated. Small rather irregular fractures are common and usually contain a dark lustrous mineral, possibly hematite. Bands of quartzose sandstone, brown shale that is commonly cut by sedimentary intrusions, and argillaceous quartz siltstone continue for another foot (30 cm).

The next 410 feet (125 m) of section is made up almost entirely of quartz arenite (Photo 14). Grain size is variable with the rock in the middle part being finer grained than at the top and bottom. Hematitic horizons are abundant. The uppermost 85 feet (25 m) are composed of quartz arenite, green shale, brown shale, and abundant intraformational breccia consisting of shale fragments in quartz arenite. Intraformational breccias are common in fine-grained beds.

Crossbedding is common in the sandstones of the formation. Ripple-marks are almost ubiquitous in the fine-grained parts of the section. The "fossils" previously mentioned occur where shale and quartzite beds adjoin. A study of the clay minerals may give a clue as to the possible cause of these features and also a reason for the abundance of sedimentary intrusions which seem to be genetically related to the fine-grained beds, particularly those which are green. What are normally described as 'mudcracks' in outcrop are common in the fine-grained beds.

Thin sections indicate that the rock types may be put into three basic categories: quartz arenite, quartz wacke-subarkose, and siltstone-shale.

Quartz Arenite

Quartz arenite can be divided into two types:

a) Equigranular
b) Bimodal or inequigranular

ODM9053

Photo 14–Crossbedded quartz arenite, Bar River Formation, Semiwite Lake. Note the sharp truncation of the crossbed, considered to have been caused by eolian conditions.

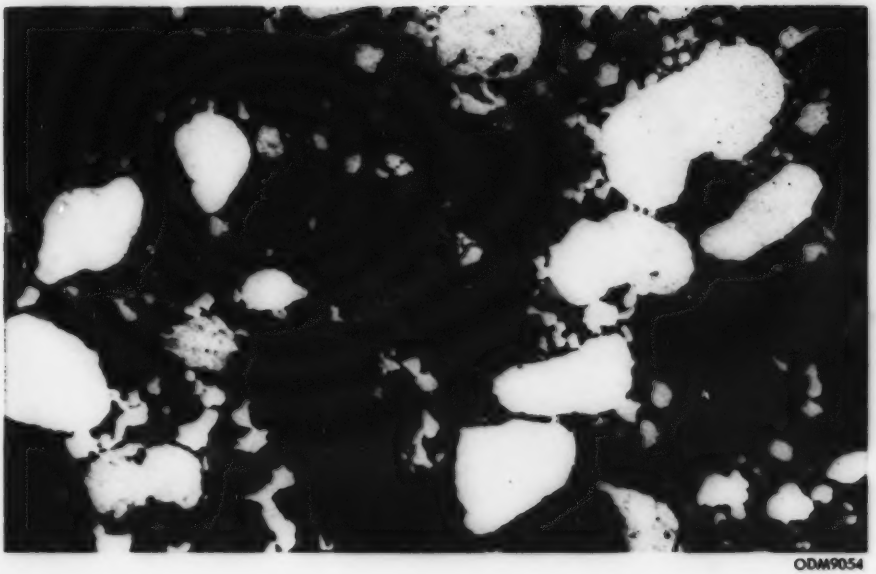
EQUIGRANULAR QUARTZ ARENITE

The equigranular quartz arenite is made up of more than 95 percent quartz, along with some grains of tourmaline, zircon, and chert. Most of the quartz grains may be of igneous origin. Some vein quartz is present and, also, some pegmatitic quartz grains with muscovite crystals preserved within them. Dust trains are assumed to represent the original shapes of the clastic quartz grains. Many of the dust trains meet and this suggests that the quartz grains were in contact with one another prior to cementation.

Based on dust trains around the grains, the average estimated roundness is 0.6 and average estimated sphericity is 0.87. Chert grains have lower values of roundness and sphericity, i.e. 0.40 and 0.75 or less, respectively. A typical average clast diameter would be 0.5 mm. Grain size varies from bed to bed, but within individual beds the grains are uniform. This indicates that they are well sorted.

BIMODAL QUARTZ ARENITE

The important feature of these rocks is the two, excluding clay matrix, distinctly different clast sizes (Photo 15). These rocks can conveniently be subdivided into



ODM9054

Photo 15–Photomicrograph of bimodal quartz arenite, Bar River Formation. This rock is considered to be a desert lag deposit. (Magnification 30X)

two varieties according to the cement. The more abundant of the two varieties either has a silica and clay mineral cement or no cement. Some of the occurrences which contain little cement are very friable. The other variety has hematite as a cementing agent. Except for a slightly greater matrix content, i.e. 5 percent of the total rock, the mineralogy of the bimodal quartz arenites is identical to that of the unimodal quartz arenite.

The average apparent diameter of the larger clasts is 0.55 mm whereas that of the smaller clasts is 0.06 mm. Average estimated roundness of the larger clasts is 0.39, average estimated sphericity exceeds 0.85. Values for these parameters in the finer grained part are 0.35 and 0.79 respectively and some of the quartz clasts have sharp outlines whereas others have 'frayed' edges. The mineralogy and texture of the second variety of bimodal quartz arenite are similar to those of the first variety. However the cement in this rock type is hematite which may exceed 10 percent of the total rock.

Subarkose

Subarkose is found interbedded with the bimodal quartz arenite. Clastic constituents are quartz, plagioclase, microcline, tourmaline, and zircon in a kaolinite and sericite matrix. Cementation is by silica and clay minerals. Feldspar crystals are either fresh or partially altered.

The grains are fine sand-size and have roundness and sphericity values similar to those of the fine-grained material in the bimodal quartz arenites.

Quartz Wacke

The quartz wacke is virtually identical to similar rocks in the middle part of the Lorrain Formation. Quartz, chert, tourmaline, and zircon are the coarser constituents, whereas pyrophyllite and kaolinite seem to be the most important matrix minerals.

Estimated roundness and sphericity values for the larger grains, i.e. those around 0.10 mm in diameter, are 0.5 and 0.75 respectively.

Where there is a lower matrix content, cementation may be partly by silica. In some thin sections where silica is the cement, the original clastic shape of quartz grains may be outlined by pyrophyllite. Possibly this texture represents quartz grains which had a coating of clay minerals at the time of deposition.

Siltstone

The siltstone is well bedded. The bedding is either due to: (1) difference in grain size between adjacent beds; (2) internal stratification within any one bed due to the parallel orientation of micaceous minerals; (3) elongated quartz crystals; or (4) long, thin, micaceous-looking hematite crystals.

The constituents are quartz, muscovite, tourmaline, zircon, hematite, chlorite, and clay minerals.

Sedimentary Structures and Depositional Environments

GOWGANDA FORMATION

In the Quirke Lake Syncline, around Blind River, and in the Whitefish Falls area, A. T. Ovenshine (1965), Casshyap (1967), Chandler (1969), and D. A. Lindsey (1967) have documented many different sedimentary structures in the Gowganda Formation. Poor rock exposures in the map-area prevented detailed study of such structures. Perhaps the only 'new' sedimentary feature is the presence of dropped stones in banded arkose.

Directional Sedimentary Structures

No directional sedimentary structures were found in any of the outcrops within the area under study. Because of extreme induration, no attempt was made in the field to measure clast orientation in the conglomerates.

Origin of the Gowganda Formation

Dating from A. P. Coleman's work in 1907 (Coleman 1908), more material has been written and probably more studies have been done on the Gowganda Formation than on any other Huronian Formation, except possibly the Matinenda Formation which is so important economically. Two Ph.D. theses have been written specifically on the Gowganda Formation (Ovenshine 1965; Lindsey 1967). At least another three have included the Gowganda Formation as an integral part (Hay 1963; Casshyap 1967; Chandler 1969) and the Gowganda Formation was the subject of one M.Sc. thesis (Schenk 1960). Many government survey workers and some industry workers have been involved. Opinions have varied, but the three most recent workers, Lindsey, Ovenshine, and Chandler, all concluded that the deposition of the rocks of the formation was intimately connected with glaciation. Young has also recently favoured the glacial hypothesis and he and Chandler (1968) have suggested that the Ramsay Lake Conglomerate and the Bruce Conglomerate, two formations in the lower Huronian sequence, are also glacial. Robertson (1969b) has published similar conclusions. Young (1970) has proposed a very extensive Lower Proterozoic glaciation in North America.

Some rocks in the formation were probably deposited directly from glaciers; others are undoubtedly water-laid, although certain characteristics may be indirectly related to glacial activity. Still others remain problematical.

The paraconglomerates are probably fossil tills. The origin of such rocks, i.e. with a wacke matrix and larger clasts, has been discussed for almost a century. J. C. Crowell and E. L. Winterer (1953) and R. H. Dott, Jr. (1961) have compared such rocks to turbidity current and slump deposits of flysch basins. The geological situation in the map-area would effectively rule out such an origin, inasmuch as the Gowganda sediments were deposited on a granitic craton near the edge of a depositional basin in an onlap situation. There is a possibility that the paraconglomerates and wacke-argillites may have been deposited by subaqueous mudflows for which the most likely source material would have been contemporaneous glacial deposits.

The bedded orthoconglomerates are almost certainly water-laid. The mode of deposition of the basal orthoconglomerate is problematical. There is no bedding visible in the matrix nor is there gross stratification of the boulders. If the medium of transportation and deposition had been water, then the environment would have been of such great energy that bedding of the conglomerate matrix would not have occurred. Indeed it is unlikely that any matrix would have been deposited. If the medium had been ice, then the results would have been similar.

The basal orthoconglomerate may be a lodgment till. The conditions of transportation and deposition of this sediment were probably frigid.

The laminated arkose with dropped stones is also unusual. Laminated arkoses with graded bedding and dropped stones are rare. Both the laminated argillites and arkoses were deposited in quiet water, possible lacustrine conditions. Sedimentation must have been in pulses and the water must have been quiet to allow development and preservation of fine laminations. The presence of dropped stones in Precambrian rocks can be satisfactorily explained only by ice-rafting. The pulses of sediment might be explained by periodic glacial melting, possibly diurnal or annual. These arkoses were, therefore, probably deposited in a frigid climatic regime.

It would, therefore, appear that some of the rocks in the Gowganda Formation are water-laid. However there is good evidence for a frigid climatic regime during that time and some of the sedimentary rocks, especially the paraconglomerates and wacke-argillites, may be related to glacial activity.

LORRAIN FORMATION

Lower Arkose Member

The presence of trough crossbeds and grain imbrication together with the gritty, pebbly, poorly sorted characteristics of the sedimentary rocks in the lower part of the formation suggests that conditions of deposition were turbulent. In only a small number of the trough crossbeds could the direction of the axial plane be determined. The measured axial directions of three crossbeds are subparallel. This and the trough-like form of the crossbeds suggest that the original sediments were deposited in a fluvial regime. The unweathered nature of the detritus constituting the lower part of the formation can be easily reconciled with the suggested glacial origin of some of the Gowganda Formation rocks. The land surface, freshly scraped by the Gowganda ice sheets and vigorously eroded by streams, would have assured a large supply of unweathered detritus. Materials derived from erosion of earlier deposited glacial sediments would also have been relatively unweathered. The crossbeds present in most of the lower part of the formation suggest that either a rising water level or a subsiding depositional basin kept pace with the inpouring of sedimentary material.

Towards the close of or at the end of the period of arkosic deposition, chemical weathering due to an ameliorating climate must have begun to exceed the rate of erosion. This is attested to by the lack of feldspars and presence of kaolinite in the middle part of the Lorrain Formation. At the end of the arkosic deposition there was either a drop in water level or uplift of the land due to isostatic adjustment caused by the melting of the Gowganda ice sheets. This resulted in the emergence of the sediments which remained emergent long enough for the breakdown of the feldspars to produce kaolinite, diaspore, and pyrophyllite. The climate during this time must have been tropical with seasonal fluctuations. This climate coupled with the laterization resulted in the association of hematite beds with aluminous minerals.

Middle Conglomerate Member

Chandler (1969) and Hadley (1968) suggested that the middle conglomeratic member of the Lorrain Formation was deposited in a beach environment. The author has no evidence to either corroborate or disprove this suggestion, but feels that a fluvial environment is more likely.

A few crossbeds measured from this part of the formation and a pebble orientation study made for International Bibis Tin Mines Limited (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie) indicate that cur-

rents responsible for pebble orientation flowed from N70W to S70E. They are more suggestive of a fluvial than a beach environment.

Some of the beds in this member show a distinct bimodality with size modes approximately 0.8 mm and 0.09 mm. R. L. Folk (1968) concluded that bimodal sediments with such a grain size are found in eolian environments (see later section on 'Bar River Formation'). Such eolian reworking is to be expected when an unlithified sediment is raised above the water-table. It is, therefore, suggested that this part of the formation, rather than being a beach deposit, is a fluviatile deposit. The interbedded conglomerate and sandstone are a result of possible seasonal fluctuations in climate.

Upper Quartz Arenite Member

The upper quartz arenite member of the Lorrain Formation is enigmatic. If the dip directions in the crossbeds (Figure 3a) are truly representative, they indicate an essentially undirectionaly current regime that was probably fluvial yet the supermature nature of the rock is not consistent with most fluvial deposits. If it is a "second cycle" sediment, it must have been derived from more northerly Lorrain sediments, since there would be no other suitable source.

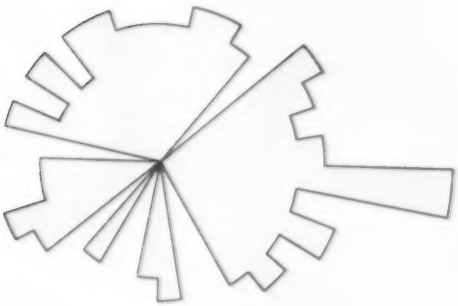
A second possibility is that there may have been a change in the fluvial regime, such that water flow was generally relatively slow. If the base-level remained fairly stable, (contrast the lower Lorrain) the rivers would have performed more of a sorting and winnowing role rather than merely a dumping one. It is possible that relief was much lower than at any time since the beginning of deposition of upper Huronian sediments. Unless significant source area uplift had occurred during the time of deposition of these sediments, the volume of these sediments necessitates that the source area must have suffered considerable erosion and peneplanation. Under these conditions rivers would be running slower, erosion would be less, stream load would be less, and chemical weathering would be at a maximum. This decrease in source area elevation could, therefore, possibly account for the supermature characteristics of the upper Lorrain sedimentary rocks.

GORDON LAKE FORMATION

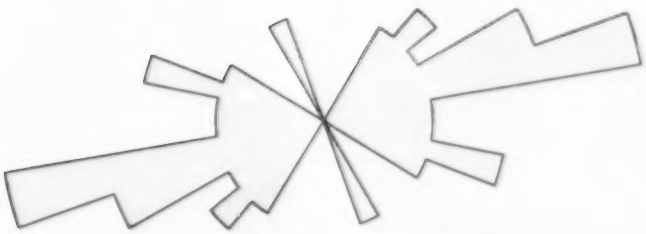
Casshyap (1967) suggested that the Gordon Lake Formation was the distal, deeper water equivalent of the Lorrain Formation. The author does not consider this possible primarily because of the mineralogical differences between the formations. The relative abundance of feldspar in the Gordon Lake Formation as compared to the upper part of the Lorrain Formation is especially noticeable. In addition, the Lorrain Formation appears to have been deposited in deeper water than the Gordon Lake Formation, and this is difficult to explain if the two are equivalent and the source area was to the north.

The Gordon Lake Formation has many of the attributes of a tidal flat environment. The two best documented present-day tidal flats are the North Sea shorelines particularly those of the Netherlands (van Straaten 1961) and the Colorado River

a. 19 crossbeds, Upper Lorrain Formation.



b. 74 crossbeds, Bar River Formation.



c. 22 ripple-marks, Bar River Formation.

SMC 12689

Figure 3–Rose diagrams of crossbed dip directions and ripple-mark strike directions.

delta (Thompson 1968). Many of the features of the Colorado River delta are identical to features of the Gordon Lake Formation. The occurrence of chert, graded bedding, ooliths, intraformational breccia, and even sedimentary intrusions can be explained if the Gordon lake sediments were deposited in a tidal flat environment.

One of the major problems of the Gordon Lake Formation is the small grain size of most of the sedimentary rocks. Many writers including F. J. Pettijohn (1957), A. O. Fuller (1961; 1962), J. W. Rogers, W. C. Krueger, and M. Krog (1963), and I. J. Smalley and C. Vita-Finzi (1968) noted the apparent deficiency of sediment particles in the range of 0.02 mm to 0.05 mm. Much of the Gordon Lake sedimentary material falls in this size range. Rogers *et al.* (1963) concluded that the deficiencies in this size range were real and not necessarily caused by sorting; that silt-size particles which are usually angular represent chips broken from larger grains; and that abrasion of sand-size grains below 2 mm is inconsequential.

Smalley (1966) concluded that glacial grinding of quartz could produce loess-size (0.22 mm-0.05 mm) material, whereas he and Vita-Finzi (1968) in a study of loess deposits of the world concluded that in warm deserts spalling (breaking off of the corners) of quartz grains could account for the small amounts of loessic material present there.

P. H. Keunen (1969) stated that eolian action does not produce quartz particles between 20 and 50 microns either by abrasion or by spalling, but pointed out that disintegration of fine-grained rocks, such as phyllites, and even of coarser grained rocks is a much more significant supplier of loessic materials. He also concluded, as did Smalley and Vita-Finzi, that glacial action is of prime importance in providing large volumes of silt-size quartz particles.

J. A. Udden (1898) showed empirically that wind suspends and carries particles finer than about 1 mm.

The Gordon Lake sedimentary rocks are largely composed of loess-size quartz particles. The opinions just presented indicate that glacial action may be of prime importance in the provision of loessic material. Acceptance of this conclusion implies that the clastic sedimentary material of the Gordon Lake Formation was produced by glacial action. Loessic deposits by definition are windblown and may occur in areas devoid of other evidence of a frigid environment. Tidal flat sedimentation mainly involves sediment distribution and bears no implication regarding the origin of the sediment. It is possible that the loess-size material which comprises the Gordon Lake sedimentary rocks was initially produced by glacial action, was subsequently blown into the basin of deposition, and was there redistributed and deposited in a tidal flat environment.

BAR RIVER FORMATION

From field evidence such as the presence of crossbedded sandstone and siltstone with ripple-marks and mudcracks, the Bar River Formation appears to have been deposited in shallow water with fluctuations of the water level. The multiplicity of crossbed dip directions indicates a beach environment.

A rose diagram showing a multiplicity of crossbed dip directions (Figure 3b)

suggests a beach environment rather than a fluvial one. However the presence of eolian bimodal quartz arenite in the formation may indicate a more complex interpretation, because wind direction as well as water current direction may be recorded in the rose diagram. In the field no large typically eolian crossbeds were seen. Some friable sandstone beds seen in the field were thought to have been calcareous beds from which the cement had been weathered out. However similar sandstone also occurs in drill core samples and proves to be uncemented quartz arenite composed of frosted grains. What, therefore, was initially thought to be solely an aqueous depositional environment is probably a hydrid aqueous-eolian environment. The bimodal quartz arenites have modes almost identical to those quoted by Folk (1968) for desert lags. The mode of the finer size is about 0.06 mm, whereas that of the coarser clasts is 0.55 mm giving a coarse to fine ratio of around 9:1. Folk from his own work and a study of available literature concluded that the mode of the coarse fraction usually ranged from 0.5 mm to 2 mm or 3 mm and the coarse to fine ratio ranged ordinarily from 4:1 to 8:1. There is thus a favourable comparison between the author's results and the conclusions of Folk.

The lack of vegetation in the Huronian landscape would have permitted winds to blow unchecked and would have provided no stability to any unconsolidated material; hence all such material above the water-table would have been affected by wind action. The sharp truncations of some crossbeds in the Bar River Formation may have been due to such wind action with the top of a crossbed showing the position of the paleo-water-table.

Figure 3c is a plot of the strike directions of ripple-marks in the Bar River Formation. Although most of the ripple-marks were "oscillation" ripple-marks, some were asymmetric and suggested currents flowing both northward and southward. Ripple-marks measured on present-day shorelines are commonly parallel to the shoreline. This contrasts with crossbeds which have a complex pattern of directions in a similar environment. The ripple-mark strike directions may indicate that the shoreline during deposition of the Bar River Formation had an east-northeast trend.

POST-HURONIAN INTRUSIONS

Igneous intrusions of two different ages postdate the deposition of the Huronian sedimentary rocks. These intrusions are, in order of decreasing age: Nipissing-type intrusions, dated at about 2.1 b.y. (van Schmus 1965; Hofmann 1967), and Keweenawan olivine diabase dikes of the Sudbury swarm, dated at about 1,225 m.y. (Van Schmus 1965).

NIPISSING-TYPE INTRUSIONS

One dike and several sills of Nipissing "Diabase" occur in the map-area. It is not known whether the intrusion near Little Quirke Lake is truly a sill. However this is the only such body found without the area underlain by Huronian sediments. The intrusions range in composition from gabbro to granodiorite, although most

are medium-grained quartz diabase.

The sill on the south short of Rawhide Lake is up to 328 feet (99.7 m) thick. It shows evidence of differentiation. The lowermost part is commonly gabbroic; the middle part, which is usually the thickest, is generally dioritic; and the uppermost part ranges in composition from quartz diorite to granodiorite. The granodiorite is generally medium to fine grained, reddish, and with an uneven distribution of quartz. Chalcopyrite and bornite are commonly found in these late stage felsic differentiates and are scattered throughout the intrusions. Radioactivity has been reported by Belfast Mines Limited [1955] (Mattaini, C. and B., file, Resident Geologist's Files, Ontario Ministry of National Resources, Sault Ste. Marie) from the sill on the south shore of Rawhide Lake.

The only Nipissing-type dike present within the map-area is located in the northwestern part of Viel Township and trends northeast to southwest. It cuts both Archean basement and Huronian rocks and is much larger than the pre-Huronian dikes, being up to 1,500 feet (450 m) wide and having a strike length greater than 50 miles (80 km) (Giblin and Leahy 1967). Where not exposed, it can be traced across country by aeromagnetic techniques. Field relations show that this intrusion is younger than the pre-Huronian intrusions, but older than the olivine diabases.

Differentiation of the intrusion is distinct. Composition varies from that of a quartz diabase at the edges to that of a granodiorite near the middle. Quartz is disseminated in the felsic parts. There has been late stage deuteric alteration in the more felsic part of the dike. Epidote in particular is abundant.

Some of the narrow dikes cutting the Archean rocks may be of Nipissing age. It was not possible to distinguish the narrow Nipissing dikes from narrow 'pre-Huronian' dikes during field mapping. As a result all of the narrow dikes which are either Nipissing or pre-Huronian share the same map-code.

KEWEENAWAN INTRUSIONS

The Keweenawan olivine diabase dikes of the Sudbury swarm stand out as the larger northwest- to southeast-trending dikes which transect all other bedrock units in the map-area. They range in thickness from 1,500 feet (450 m) to 20 feet (6 m). Some of the larger dikes are traceable by aeromagnetic techniques for distances exceeding 100 miles (160 km). Some smaller ones were mapped as pre-Huronian or Nipissing Diabase, inasmuch as they are quite fine grained and only a very slight difference in colour and texture serves to distinguish the two rock types. The larger dikes weather to a distinct brown colour and may show onionskin weathering. Compared to the earlier diabases, the Keweenawan olivine diabases are slightly darker and the diabasic texture is more pronounced. Individual dikes vary in thickness along strike. Overall composition is that of an olivine diabase, but composition varies from edge to centre. This variation is not visible in the small intrusions, but is very distinct in the larger medium- to coarse-grained ones. Near the edges they are dark coloured with olivine and pyroxene being the two most common minerals; towards the centre the amount of olivine and pyroxene is less and the amount of feldspar is more. Thus the colour is lighter towards the middle of an intrusion. In contrast to the pre-Huronian and Nipissing intrusions, the

feldspar in the olivine diabase is either whitish or colourless. Albite lamellae are readily visible in the phenocrysts.

METAMORPHIC RELATIONS

The Nipissing Diabase sills apparently metamorphosed the Huronian sediments more extensively than the Keweenawan olivine diabase dikes despite the fact that the latter are more mafic and were, therefore, presumably intruded at a higher temperature. Perhaps the sediments were still waterlogged when the Nipissing Diabase sills were intruded, but were already lithified and dewatered when the Keweenawan diabases were intruded. Therefore the presence of water may have allowed more extensive metamorphic effects to develop during emplacement of the Nipissing intrusions.

Cenozoic

QUATERNARY

Pleistocene and Recent sediments are present throughout the area, but these sediments were not studied in detail. Boissonneau (1968) gives a very general regional report on the Pleistocene geology. A detailed study of the Pleistocene glaciation and its effects in the map-area could be rewarding.

Glacial striae and chattermarks are present on most outcrops. These indicate a general southward direction of ice movement. There are many meltwater channels, some of the "up and down" variety, for example along the south shore of Rawhide Lake.

East of Semiwite Lake there are both small and large moraines. The morainic material is typically unsorted. The boulders and pebbles are of varied roundness and sphericity and include a wide variety of rock types. Till is present in most parts of the area, but few good exposures were found. The Pleistocene sediments are locally thick. For example near Stag Lake there are more than 200 feet (60 m) of variegated sediments (Sutherland and Associates, 1965, file, Resident Geologist's Files, Ministry of Natural Resources, Sault Ste. Marie).

Several gravel pits have been dug in the western and southern parts of the area. There are considerable reserves of sand and gravel in various places, for example east of Rosemarie Lake and east and northeast of Semiwite Lake. However they are presently unexploitable owing to inaccessibility.

Recent swamp and stream deposits are common throughout the region.

STRUCTURAL GEOLOGY

The rocks in the southern belt of Archean metamorphic rocks show a decrease in intensity of structural deformation from east to west. The lack of a distinct

schistosity in the igneous rocks near the western boundary of Hembruff Township creates problmes in trying to distinguish mafic volcanic rocks from younger mafic intrusive rocks. Farther east in Hughson Township the structure is more complicated and an intense penetrative foliation appears. Refolded foliations were seen in many locations. The suggested structural history for this area is: 1) folding along a subhorizontal east-trending axis which produced isoclinal folds and schistosity; 2) folding along almost vertical north-plunging axes. This has created an antiform south of Semiwite Lake and a synform northeast of Lucas Lake. On the limbs of these larger folds there are many smaller folds.

There are at least two generations of biotites, but the relationships between the phases of deformation and metamorphism were not determined.

As can be seen from the map (see back pocket) the Huronian sedimentary rocks are relatively gently dipping in the northern part of the area. Local dips adjacent to the basement contact are in the order of 30 degrees, but southwards in the vicinity of Rawhide Lake they decrease to about 15 degrees. The strike is fairly constant. Farther south in the vicinity of Helenbar and Semiwite Lakes, large folds have been developed. These folds have steep north-facing limbs and gently dipping south-facing ones. Near the Flack Lake Fault in the southwest arm of Semiwite Lake, disoriented blocks of sandstone are common.

The most obvious movement on the Flack Lake Fault, i.e. a downdrop to the north, occurred after deposition of the Huronian sediments. There is, however, evidence to suggest that the Flack Lake Fault may have been active with downdrop to the south prior to deposition of the Gowganda Formation. This could not be substantiated within the map-area, but west of the map-area, south and west of Flack Lake, formations as low in the stratigraphic sequence as the Elliot Lake Group abut against the fault (see Robertson 1971 *et al.*). Had the fault been inactive or had its present direction of downdrop at the time of deposition of the lower Huronian formations, lower Huronian formations would be present north of the fault. Only upper Huronian or Cobalt Group rocks have been found north of the fault. The present configuration of the Flack Lake Fault is that of a reverse fault. The dip is about 72 degrees south. This information was deduced from the orientation of exposed slickenside surfaces. The author (Wood 1968) has suggested that the folds developed in the sedimentary rocks north of the fault may be due to gravity sliding initiated by the faulting. The fold styles and scale are different from the Quirke Lake and Chiblow Anticlines and from folds found elsewhere in the Huronian rocks (W.R. Church 1969, University of Western Ontario, personal communication).

Robertson (1970b) has established that the Rawhide Lake diabase sill was intruded along a discontinuity in the Huronian sequence. He considers this discontinuity to be a thrust fault.

The faults which parallel the Flack Lake Fault have different directions of movement. The Skunk Creek Fault has a movement similar to the Flack Lake Fault with north side down and has an estimated throw of 500 feet (150 m). It is one of the more important faults in the area in that it downfaults Gowganda and Lorrain sedimentary rocks against the Archean basement. One of the faults near Semiwite Lake has its downdrop side to the south. The precise pattern of the faulting in this locality is not clear because of the abundance of glacial material.

The Little Quirke Lake Fault, the western extension of which was named the Ompa Lake Fault by Robertson in 1969, would appear from Robertson's mapping

(1969a) to be a branch of the Flack Lake Fault. It is topographically expressed by a distinct linear depression. Rocks within the fault zone are strongly sheared and in some places the shear zone may be up to 1,000 feet (300 m) wide.

In the Huronian sedimentary rocks slickensided bedding planes may be found especially near the Flack Lake Fault. Quartz veins and quartz specularite veins are generally found in association with diabase intrusions. The author considers that the latter are, therefore, responsible for these veins, in some of which drusy quartz is present.

ECONOMIC GEOLOGY

MINERAL OCCURRENCES

In this section occurrences of the various minerals which contain potentially 'economic' metallic elements will be presented in alphabetical order. This will be followed by nonmetallic mineral occurrences also in alphabetical order. The occurrences, their probable mode of origin, and their potential will be discussed.

Copper

Within the map-area copper minerals occur in igneous, sedimentary, and metamorphic rocks.

Copper Deposits in Igneous Rocks

Chalcopyrite is sporadically distributed throughout dikes and sills of Nipissing Diabase. Dikes generally show no effects of magmatic differentiation in terms of chalcopyrite or other copper minerals. The sills, however, may show concentrations of copper minerals in the upper more felsic parts. For example, the sill on the south shore of Rawhide Lake has concentrations of copper up to approximately 3 percent by visual inspection. Minerals in this particular occurrence are chalcopyrite and minor bornite. It would appear that the copper minerals were concentrated in the final stage differentiates of such intrusions.

The sill on the south shore of Rawhide Lake has been tested by pits and diamond drilling, but no development work has been undertaken. Logs of these drill holes which were put down by Belfast Mines Limited [1955] (Mattaini, C. and B., file, Resident Geologist's Files, Ministry of Natural Resources, Sault Ste. Marie) give no indication of any nickel minerals which could conceivably occur in the lower parts of such intrusions.

Approximately 3 miles (5 km) west of Little Quirke Lake on the north side of the large mafic intrusion which trends eastward across the southern part of the area, there is a quartz-chalcopyrite occurrence from which were obtained some

grab samples having up to 5 percent copper by visual estimation. Crystals of both minerals are very coarse grained and are considered to have been recrystallized during shearing along the edge of the intrusion. The potential of this occurrence is not known.

The general economic potential of the Nipissing Diabase intrusions within the map-area appears to be limited. The only intrusions with any mineral concentrations are the sills and these have a limited thickness and areal extent.

Copper Deposits in Metamorphic Rocks

The only metamorphic rocks in which copper mineralization was observed are metavolcanic. There are several occurences of such mineralization, for example west of Rooster Lake in Hughson Township and south of Semiwite Lake in Hembruff Township (see Geological Map, back pocket). Although none of these occurrences are large, they all occur where mafic volcanic rocks give way to felsic volcanic rocks in the volcanic sequence, that is they occur in that part of the volcanic sequence where massive sulphide mineralization typically occurs. The mineralogy (chalcopyrite, pyrite, pyrrhotite) is typical of a metamorphosed massive sulphide deposit. Therefore the potential of that part of the area underlain by Archean metavolcanics and metasediments should not be underestimated.

Copper Deposits in Sedimentary Rocks

The most conspicuous occurrence of copper minerals in sedimentary rocks is in the upper part of the Lorrain Formation, where chalcopyrite is present throughout the Rawhide Lake-Flack Lake area in small amounts, i.e. less than 0.2 percent Cu. There are no known concentrations of the mineral and, although there has been active exploration, for example Sutherland and Associates (18) in 1965 (Resident Geologist's Files, Ontario Ministry of Natural Resources, Sault Ste. Marie), no development has been undertaken.

The author considers that the chalcopyrite is detrital and probably was derived from erosion of an Archean massive sulphide deposit. The nature and depositional environment of this quartz arenite part of the Lorrain Formation is such that it is unlikely that concentrations are likely to exist. However if the amounts present were slightly greater and accessible for open-pit mining, there might be economic possibilities.

Chalcopyrite was observed in quartz veins in the Gordon Lake Formation, but no potentially economic amounts of chalcopyrite were seen. However this in no way precludes the possibility that such may exist, since for a short time copper was mined from the Gordon Lake Formation near Cobre Lake in Sagard Township (formerly 1A) west of Viel Township. Here the author believes that the Nipissing-type diabase sill 'soaked' the copper from the sediments and thus concentrated the copper making it economically viable.

Iron

There are several types of iron occurrences found in the map-area. The three most common iron minerals are hematite, magnetite, and pyrite.

Hematite

Hematite occurs in the Archean granitic rocks and Huronian sedimentary rocks. The occurrences in the Archean granitic rocks are minor and consist of specular hematite in ½-inch (1.25 cm) wide veinlets. These are common in the northwestern part of Viel Township.

Hematite occurs in rocks of all four Huronian formations found in the map-area.

In some Gowganda rock types the total amount of the iron oxides may exceed 15 percent. Hematite is an important oxide as is magnetite. Both are detrital and are commonly found in graded beds.

Although hematite grains are present in all rock types of the Lorrain Formation especially in crossbedded units, the most important occurrence is at the top of the arkose member and the base of the conglomeratic member, i.e. in association with radioactive and aluminous minerals. The hematite grains appear detrital, although some overgrowths are authigenic. Roscoe (1969) described these concentrations of heavy minerals (zircon is also present) as black sand-type concentrations.

In the Gordon Lake Formation there is both detrital hematite and authigenic hematite. The presence of hematite ooliths would strongly suggest that at least some of the iron oxide was chemically precipitated.

In the Bar River Formation it would appear that much of the hematite is a chemical precipitate. Some parts of the sequence strongly resemble Animikie-type iron formation.

Because of the abundance of high-grade iron ore deposits, the hematite deposits in Huronian rocks have a poor potential, but they may have some potential in the future.

Magnetite

Magnetite, in varying amounts, occurs in nearly all of the rock types in the map-area from the Archean metavolcanics to the Keweenawan diabase. The only rock type which may be potentially economic is the Archean quartz-magnetite iron formation found in the southeastern part of Hughson Township. This particular belt of sedimentary iron formation extends into the township to the east, where some exploration was carried out by Trinity Chibougamou Mines Limited [1964] (20) (Resident Geologist's Files, Ministry of Natural Resources, Sault Ste. Marie) but with no further developments. The magnetite is considered to be part detrital and part authigenic, because the atmosphere at the time of deposition was probably anoxygenic, favouring the formation of authigenic magnetite rather than authigenic hematite. The economic potential of this occurrence is, also, governed by

the market conditions referred to above. The grade of metamorphism has been insufficient to give the rock a coarsely crystalline character which would have helped beneficiation of the material; however of all the iron occurrences in the area, this is economically the most favourable.

Pyrite

Pyrite and some pyrrhotite as well occur in association with the chalcopyrite in the metavolcanics, as mentioned previously. The potential of this mineral is extremely limited.

Thorium-Uranium

Radioactivity has been noted in some rocks of the Gowganda Formation and, also, in rocks of the Lorrain Formation near the top of the arkosic part and at the base of the conglomeratic part. Little attention has been given to the Gowganda Formation rocks. However considerable exploratory work including diamond drilling has been done on the Lorrain Formation radioactive occurrences during the original uranium rush of the mid-fifties and more recently when the Mississagi Provincial Park was re-opened in 1968 for staking. The results of this latter work have been disappointing. International Bibis Tin Mines Limited (4) has determined that thorium rather than uranium is the source of the radioactivity (Resident Geologist's Files, Ministry of Natural Resources, Sault Ste. Marie). Roscoe and Steacy (1958) in analyzing samples from the township just west of Viel Township as well as possibly samples from Viel Township found that the uranium content is low in all the samples and that the thorium:uranium ratio is 8:1 which is high compared to the values obtained from the Matinenda Formation which is the formation containing the economic uranium deposits in the Quirke Lake Syncline. D. S. Robertson (1962) and R. I. Thorpe (1963) studied variations in thorium and uranium in the Blind River area. They showed that there is an increase in thorium:uranium ratios from northwest to southeast across the Quirke Lake Syncline and related this to the rather poor transportability of uranium minerals compared to stable thorium minerals such as monazite. The Lorrain Formation locally rests directly on Archean basement rocks in the area mapped. Assuming the source of uranium and thorium to be the same as that during deposition of the Matinenda Formation, the thorium:uranium ratio should be lower in the Lorrain Formation than in the Matinenda Formation of the Quirke Lake Syncline. Perhaps the source area at the time when the Lorrain was deposited had a different thorium:uranium ratio from the source area when the Matinenda Formation was being laid down. Another possibility is that the physiocochemical conditions during weathering of the source rock and the conditions of transportation and deposition of the resultant detritus may have changed during the time interval between deposition of the Matinenda Formation and the Lorrain Formation.

The author believes that a fundamental step in the evolution of the earth's atmosphere took place in the time interval between deposition of the Matinenda Formation and deposition of the Lorrain Formation, namely a change from a reducing atmosphere to an oxidizing one (cf. Roscoe 1969). Since uranium is a readily oxidized element and since it is highly soluble in its higher oxidized form, it is very unlikely that Blind River type uranium deposits will be found in upper Huronian or younger rocks. The author, therefore, considers the potential of the Lorrain radioactive occurrences as very limited unless a market for thorium should develop. Under these circumstances the potential would be good.

The Gowganda occurrences are considered to be limited in potential.

Quartz

The uppermost part of the Lorrain Formation is being mined near Whitefish Falls by The International Nickel Company of Canada Limited and part of the Bar River Formation is being mined on Badgeley Island by Indusmin Limited for use as a smelter flux. Such an exceptionally pure quartzite as found in these localities does not occur in either the Lorrain or Bar River Formations of the Rawhide Lake area. However quartz arenites with greater than 95 percent quartz do occur and have a potential as a silica source.

Sand and Gravel

The area has considerable potential as a source of these commodities. Several pits have been developed and are occasionally used.

DESCRIPTION OF PROPERTIES

Data which have been filed for assessment credit in the Rawhide Lake area are summarized in Table 3. Only properties on which significant work has been done are described in the text.

Canadian Conquest Mines Limited (1)[1] and Rawhide 'U' Mines Limited (6)

The Rawhide 'U' Mines Limited property is southeast of the C. and B. Mattaini (5) property; similarily the Canadian Conquest Mines Limited property lies to the southeast of that. Exploration on both properties was carried out in 1969. The geology is similar to that of the C. and B. Mattaini property, and it would appear that the search was also for uranium. Maximum amounts of mineralization quoted

[1]Number in brackets refers to property number shown on Maps 2305 and 2306, back pocket.

Table 3 ASSESSMENT WORK ON FILE FOR RAWHIDE LAKE AREA[1]

	Property Number	Name of Property	No. of Claims	Year Work Done	Type of Work Done	Drilling	Toronto File No.
Viel Township[2]	1	Canadian Conquest Mines Ltd.	13	1969	GL-map	1-320 (100)	Viel Tp.[2] Rept. 11
	2	Gaitwin Explorations Ltd. [1955]	12	1953	GL-map		63A.171
		Gaitwin Explorations Ltd. [1955]	12	1955	GL-map	1-990 (300)	Viel Tp.[2] Rept. 12
		Gaitwin Explorations Ltd. [1955]	Part of 36 group	1955	GL-map		63A.257
	3	Hollinger Mines Ltd.	2 + 2 parts	1969	GP-A EM, mag	—	63.2491
		" " "	"	"	GL-map; GP-G RA, Mag, EM	—	63.2460
	4	International Bibis Tin Mines Ltd.	7	1968	GL-map; GP-G spec and Mag	—	63.2455
	5	Mattaini, C. and B. (Belfast Mines Ltd. option) [1955]	16	1954	GP-A RA		63.477
				1955	GL-8 pits	6-4,528 (1380)	Viel Tp.[2] Rept. 13
	6	Rawhide 'U' Mines Ltd.	16	1969	GL	3-1,002 (305.4)	Viel Tp.[2] Rept. 10
	7	St. Denis, A	27	1969	GP-A EM, Mag	—	63.2477
	8	Weston, D.	6	1969	GL-map	—	63A.545
Piche Township[2]	9	Consolidated Golden Arrow Mines Ltd.	7	1968	GL-map; GP-G RA	—	63.2358
	10	Hanson, A. and W. [1953]	60	1953	GL-3 tr	6-1,822.5 (555.45)	5.6.391
	11	Hollinger Mines Ltd.	6 + 2 parts	1969	GP-A EM, Mag	—	63.2491
		" " "	"	"	GL-map; GP-RA, Mag, EM	—	63.2460
	12	Mayfair Mines Ltd.	15	1969	GP-G Mag, scint	—	63.2575

Hembruff Township[1]	13	Apex Consolidated Resources Ltd. [1955]	49	1955	GL-map; GP-G Mag	—	63.608
	14	Atkins, W. F.	37	1970	GP-A EM, Mag	—	63.2800
	15	Gaitwin Explorations Ltd. [1955]	Part of 36 group	1955	GL-map	—	63A.257
	16	North Inca Mines Ltd. [1956]	18	1956	GL-map; GP-G Mag	—	63.709
	17	Schramm, J.	6	1969–70	GL	3-271 (82.4)	Hembruff Tp.[4] Rept. 14
	18	Sutherland and Associates	199	1964–65	GL	12-8,247 (2,514)	Hembruff Tp.[4] Rept. 10, 11, 12, 13
		" " "	"	1968	GP-A Mag, scint, EM	—	63.2464
Hughson Tp.[5]	19	St. Denis, A.	64	1969	GP-A EM, Mag	—	63.2477
	20	Trinity Chibougamau Mines Ltd. [1964]	6 + part of 6	1964	GP-A Mag	—	63.1451

[1]Assessment Files Research Office, Ontario Division of Mines, Toronto
[2]Formerly Township U.
[3]Fomerly Township Q. 1-990 (300)-1 hole 990 feet total 300 meters
[4]Formerly Township 151.
[5]Formerly Township 145.

A – Airborne
EM – Electromagnetic
G – Ground
GL – Geological
GP – Geophysical
Mag – Magnetic
RA – Radioactive
tr – trenches
scint – scintillometer
spec – spectrometer

in the Rawhide 'U' Mines drill logs covering 1,002 feet (305.4 m) of drilling are 0.03 percent U_3O_8 and 0.02 percent ThO_2 (Resident Geologist's Files, Ministry of Natural Resources, Sault Ste. Marie). Results of the Canadian Conquest Mines Limited drilling were even less favourable.

Gaitwin Explorations Limited [1955] (2)

Gaitwin Explorations Limited started work on their Rottier Lake property in 1953 with a geological survey. This was followed up in 1955 by diamond drilling to a depth of 990 feet (300 m). No significant mineralization was encountered. The property is wholly underlain by sedimentary rocks of the Lorrain Formation. The contact between the arkosic member and the quartz wacke-quartz and jasper pebble conglomerate member passes east-west through the property. It is at this horizon that radioactive minerals occur. The collar of the drill hole lies below this general horizon. There is some minor faulting in this locality.

A. and W. Hanson [1953] (10)

The Hanson property straddles the ground between Rawhide and Rosemarie Lakes and is stratigraphically at the same horizon as the Rottier Lake property of Gaitwin Explorations Limited. Northwest-trending olivine diabase dikes transect the Lorrain sedimentary rocks. The pits and diamond drilling performed in 1953 would seem to have been aimed at evaluating the previously mentioned radioactive horizon. The best intersection recorded from a total of six holes and 1,822.5 feet (555.45 m) of drilling was 0.44 lbs. U_3O_8 over 3.5 feet (1.1 m).

C. and B. Mattaini [1955] (5)

(Belfast Mines Limited)

In 1954 a group of 16 claims was staked on the south shore of Rawhide Lake by C. and B. Mattaini. An airborne radioactivity survey was conducted that year and in 1955 Belfast Mines Limited did work on claims of this group, the primary target of exploration being uranium. Eight pits were excavated and six holes totalling 4,528 feet (1,380 m) were diamond drilled. The property is underlain by the 'diabase' sill which trends east-west across the area and by quartz wacke of the Lorrain Formation. Within the limits of this property the sill shows magmatic differentiation effects from gabbro to granodiorite, and it is in the granodiorite (or 'granophyric') part that the segregations of chalcopyrite, bornite, and radioactive minerals, which were tested by trenching, occur. The best analysis reported in the drill logs was 0.24 percent U_3O_8 (radiometric). A repetition of rock types recorded in the logs suggests that the sill might be a multiple intrusion. No evidence was found in the field to either confirm or refute this impression. The logs do not show any association of rock type with mineralization.

J. Schramm (17)

The three main rock types underlying the Schramm property are: Archean felsic volcanic rocks, Archean granitic rocks, and a gabbro diorite than can possibly be correlated with the Nipissing Diabase. The northwestern part and part of the southern edge of the property is underlain by the granitic rocks whereas the main central parts of the six claim group are underlain by the mafic intrusion. The mafic intrusion forms part of a much larger body stretching across the southern part of the map-area. Within the claim group there is at least one showing of copper mineralization which has been trenched. The three drill holes in the two central claims appear to have been drilled in order to test for copper mineralization. No results of significance are reported in the drill logs. The Little Quirke Lake Fault is just north of the property.

Sutherland and Associates (18)

Sutherland and Associates hold a total of 199 claims in the Stag Lake area. The geology of this group can best be seen from the main map. A large part of the claim group is devoid of outcrop and covered by swamp. The Lorrain, Gordon Lake, and Bar River Formations, a Nipissing Diabase sill, and a Keweenawan olivine diabase dike underlie the property. The Gordon Lake Formation is areally most extensive. However the mineralization of interest occurs in the upper part of the Lorrain Formation, that is below the Gordon Lake Formation. The main mineral is chalcopyrite, and in drill logs of the 12 holes totalling 8,247 feet (2514 m) drilled in 1964-1965, the highest analysis was 0.86 percent Cu. Mineralization was encountered from near surface to depths in excess of 1,100 feet (335 m). There seems to be no spatial relationship between mineralization and diabase sills or dikes. Airborne magnetometer, electromagnetic, and scintillometer surveys were conducted in 1968.

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